US009077797B2

(12) **United States Patent**
Saini et al.

(10) **Patent No.: US 9,077,797 B2**
(45) **Date of Patent: *Jul. 7, 2015**

(54) **SYSTEM AND METHOD FOR QUALITY AUTO-BLENDING IN CALL ROUTING**

(71) Applicant: **Tata Communications (America) Inc.**, Herndon, VA (US)

(72) Inventors: **Aakratee Saini**, Monroe Township, NJ (US); **Avanish Pande**, Spotswood, NJ (US); **Joseph F. Conrey**, Spring Lake, NJ (US); **Roy Ho**, Morganville, NJ (US)

(73) Assignee: **Tata Communications (America) Inc.**, Herndon, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/319,020**

(22) Filed: **Jun. 30, 2014**

(65) **Prior Publication Data**

US 2014/0314224 A1 Oct. 23, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/770,103, filed on Feb. 19, 2013, now Pat. No. 8,787,541.

(51) **Int. Cl.**

H04M 15/00	(2006.01)
H04M 7/00	(2006.01)
H04M 3/36	(2006.01)
H04M 7/12	(2006.01)
H04Q 3/66	(2006.01)

(52) **U.S. Cl.**

CPC ***H04M 3/367*** (2013.01); ***H04M 7/128*** (2013.01); ***H04M 7/1285*** (2013.01); ***H04Q 3/66*** (2013.01); *H04Q 2213/13141* (2013.01); *H04M 15/8044* (2013.01)

(58) **Field of Classification Search**

CPC H04M 15/00; H04M 15/58; H04M 3/4228
USPC 379/112.01, 112.05, 112.1, 220.01, 379/221.01, 221.06, 221.07, 221.14
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,999,604	A *	12/1999	Walter	379/133
7,076,036	B1	7/2006	Johnson	
8,355,485	B2	1/2013	Schultz	
8,463,939	B1	6/2013	Galvin	
2006/0133282	A1	6/2006	Ramasamy	
2007/0195700	A1 *	8/2007	Katoh et al.	370/235
2008/0198998	A1	8/2008	Aleynikov	
2010/0149984	A1	6/2010	Kapoor et al.	

OTHER PUBLICATIONS

"Related U.S. Appl. No. 13/770,103", "NonFinal Office Action", Nov. 5, 2013, Publisher: USPTO, Published in: US.

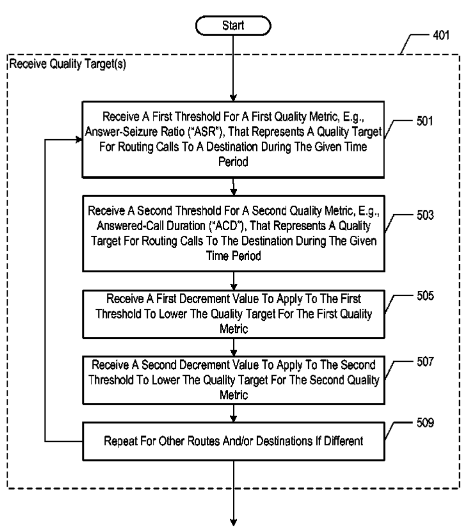
(Continued)

Primary Examiner — Quoc D Tran
(74) *Attorney, Agent, or Firm* — Kaplan Breyer Schwarz & Ottesen, LLP

(57) **ABSTRACT**

A system and method blend particular quality considerations into the process of expanding the route choices in a route table, such that more calls can be successfully routed while maximizing certain objectives. The quality considerations drive how additional routes are chosen for the route table and how call volumes are allocated to the chosen routes so that overall profitability can be maximized within the governing constraints of quality targets, route quality, predicted traffic, and route capacity.

17 Claims, 16 Drawing Sheets



(56) **References Cited**

OTHER PUBLICATIONS

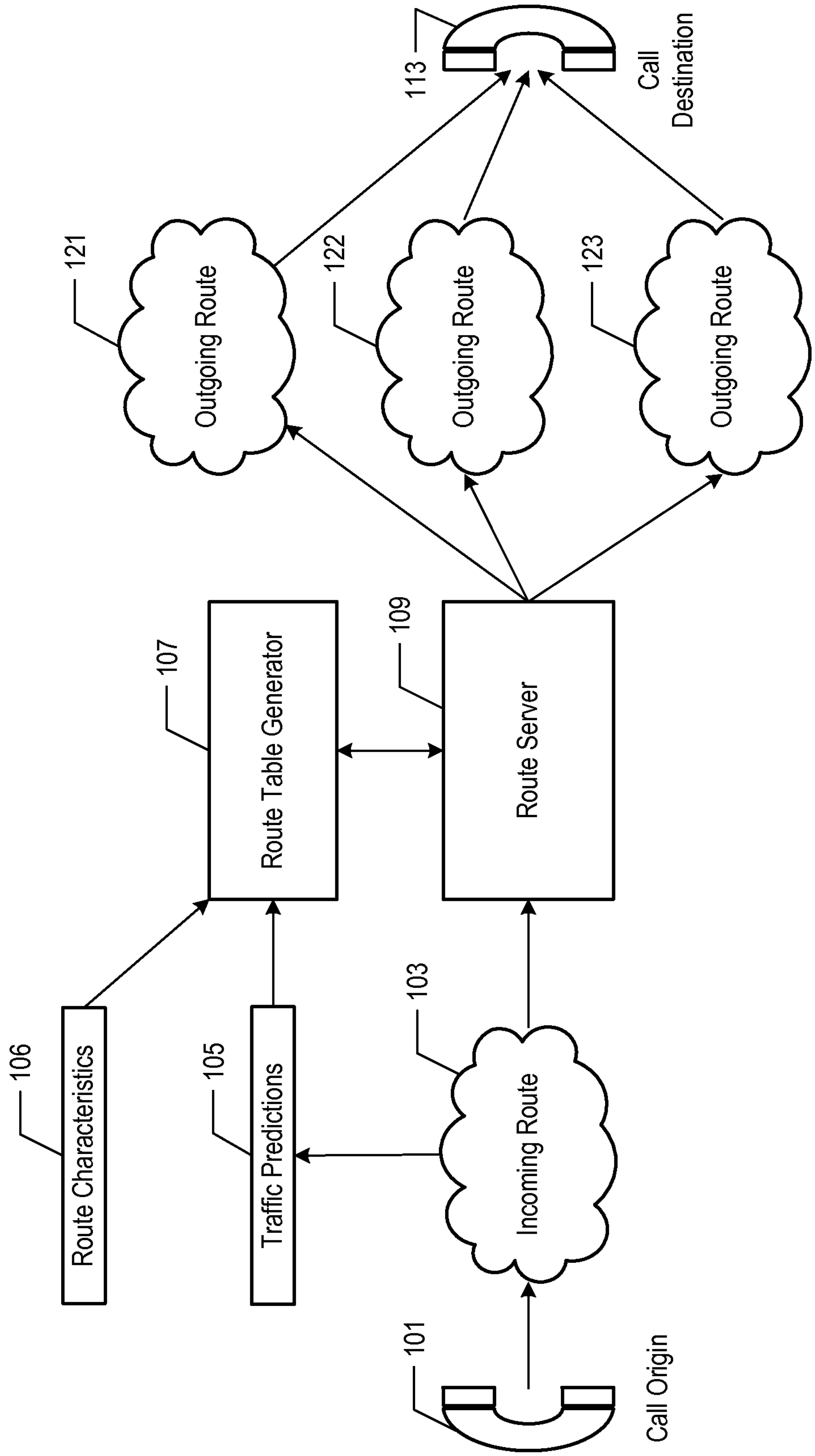
"Related U.S. Appl. No. 13/770,103", "Notice of Allowance", Mar. 6, 2014, Publisher: USPTO, Published in: US.

Officer: Ken Weider, "International Patent Application No. PCT/US14/16805", "International Search Report and Written Opinion", Mar. 21, 2014, Publisher: PCT, Published in: US.

* cited by examiner

Figure 1A (Prior Art)

Telecommunications System 100



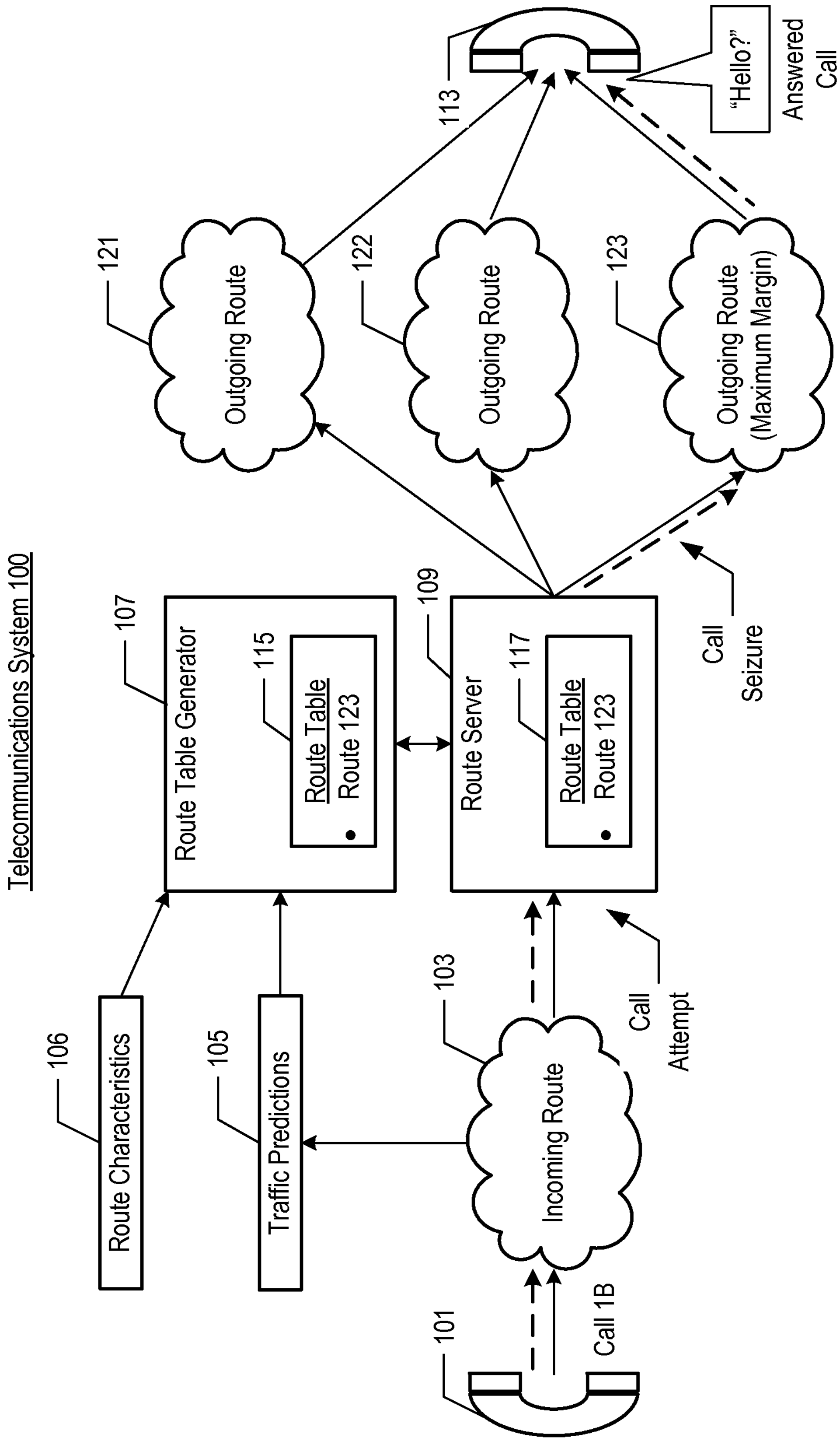


Figure 1B (Prior Art)

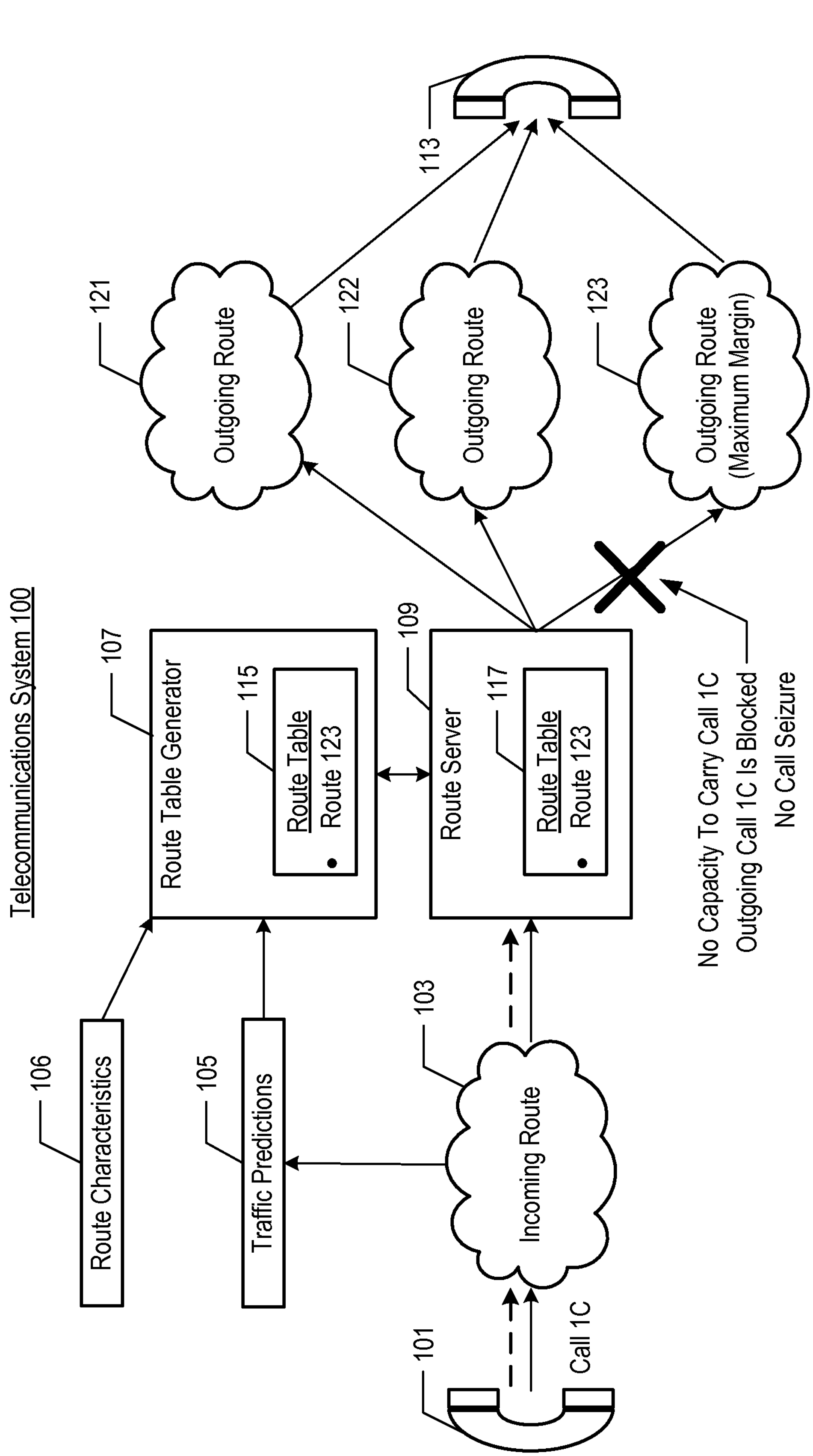


Figure 1C (Prior Art)

Figure 2A

Telecommunications System 200 (Quality Blending)

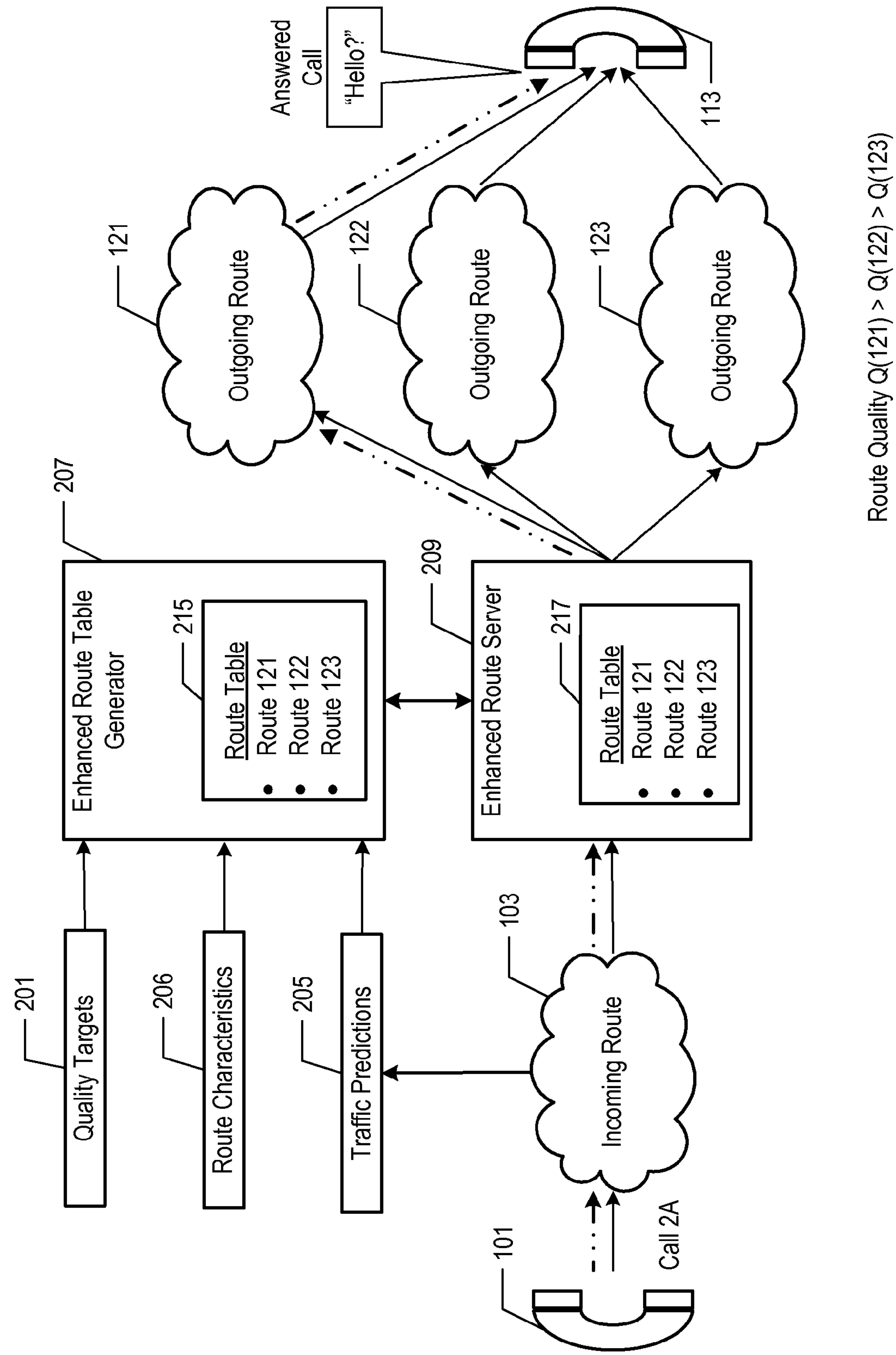


Figure 2B

Telecommunications System 200 (Quality Blending)

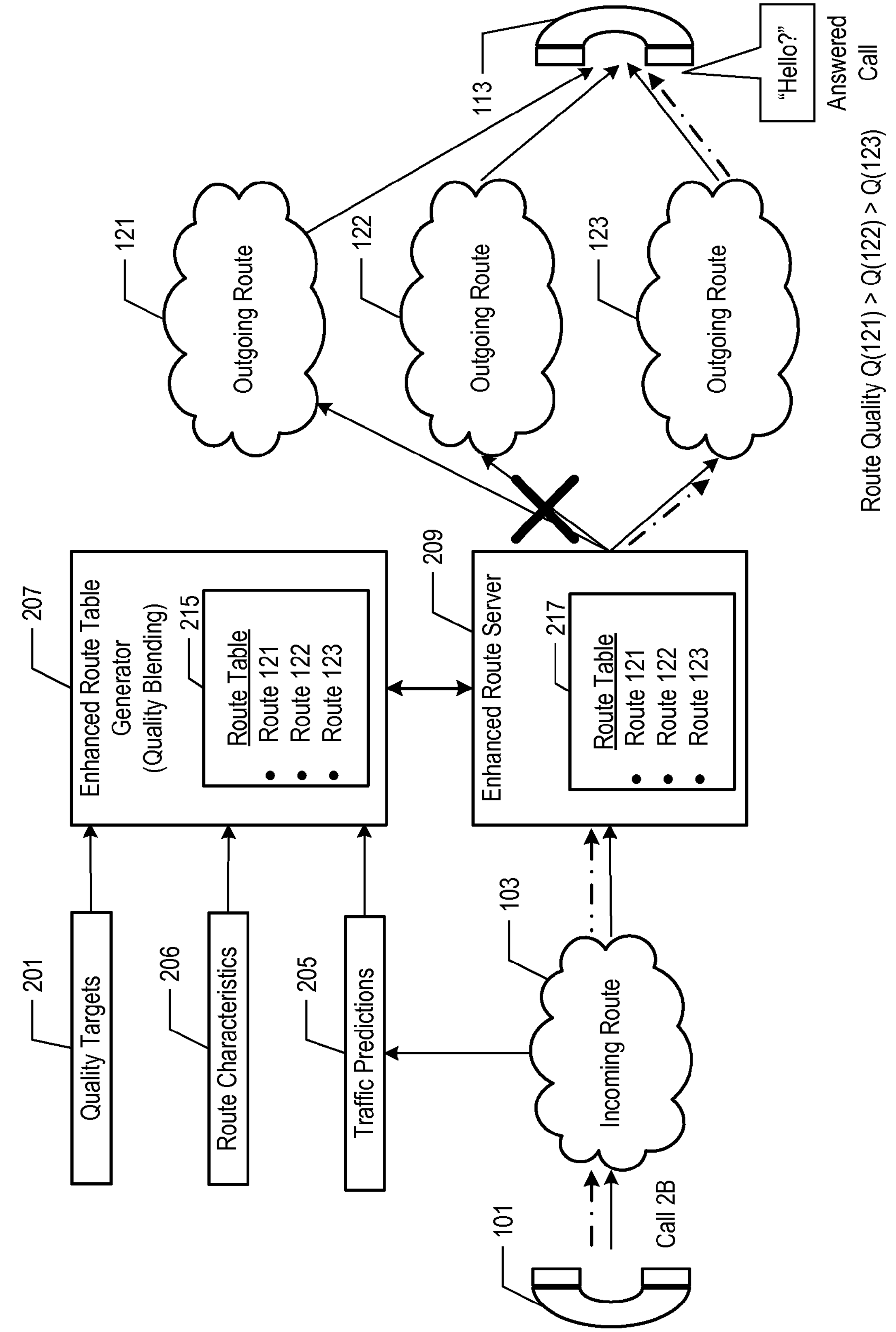


Figure 3A

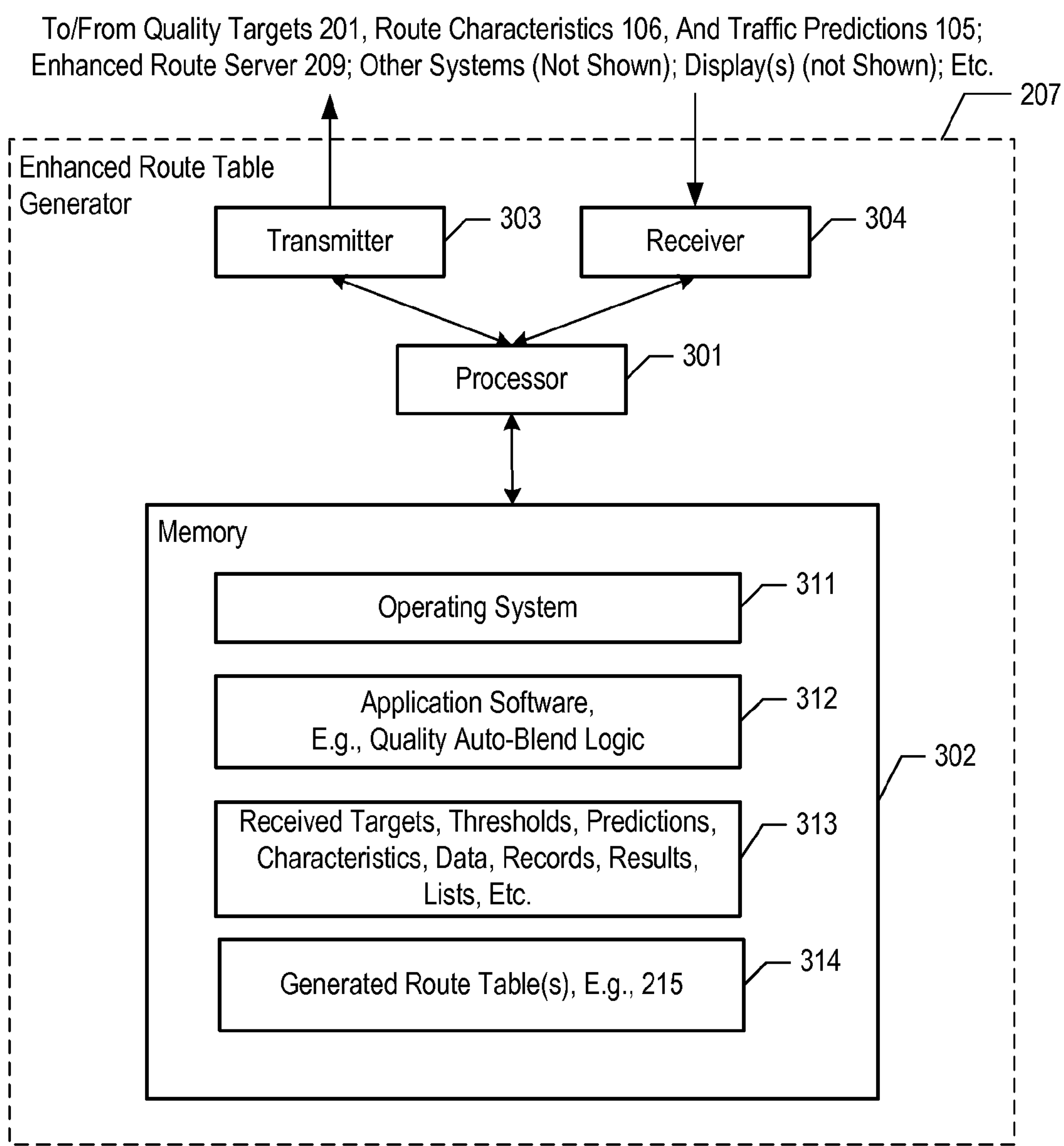

To/From Quality Targets 201, Route Characteristics 106, And Traffic Predictions 105;
Enhanced Route Server 209; Other Systems (Not Shown); Display(s) (not Shown); Etc.
207
Enhanced Route Table Generator
Transmitter
303
Receiver
304
Processor
301
Memory
Operating System
311
Application Software, E.g., Quality Auto-Blend Logic
312
302
Received Targets, Thresholds, Predictions, Characteristics, Data, Records, Results, Lists, Etc.
313
Generated Route Table(s), E.g., 215
314

Figure 3B

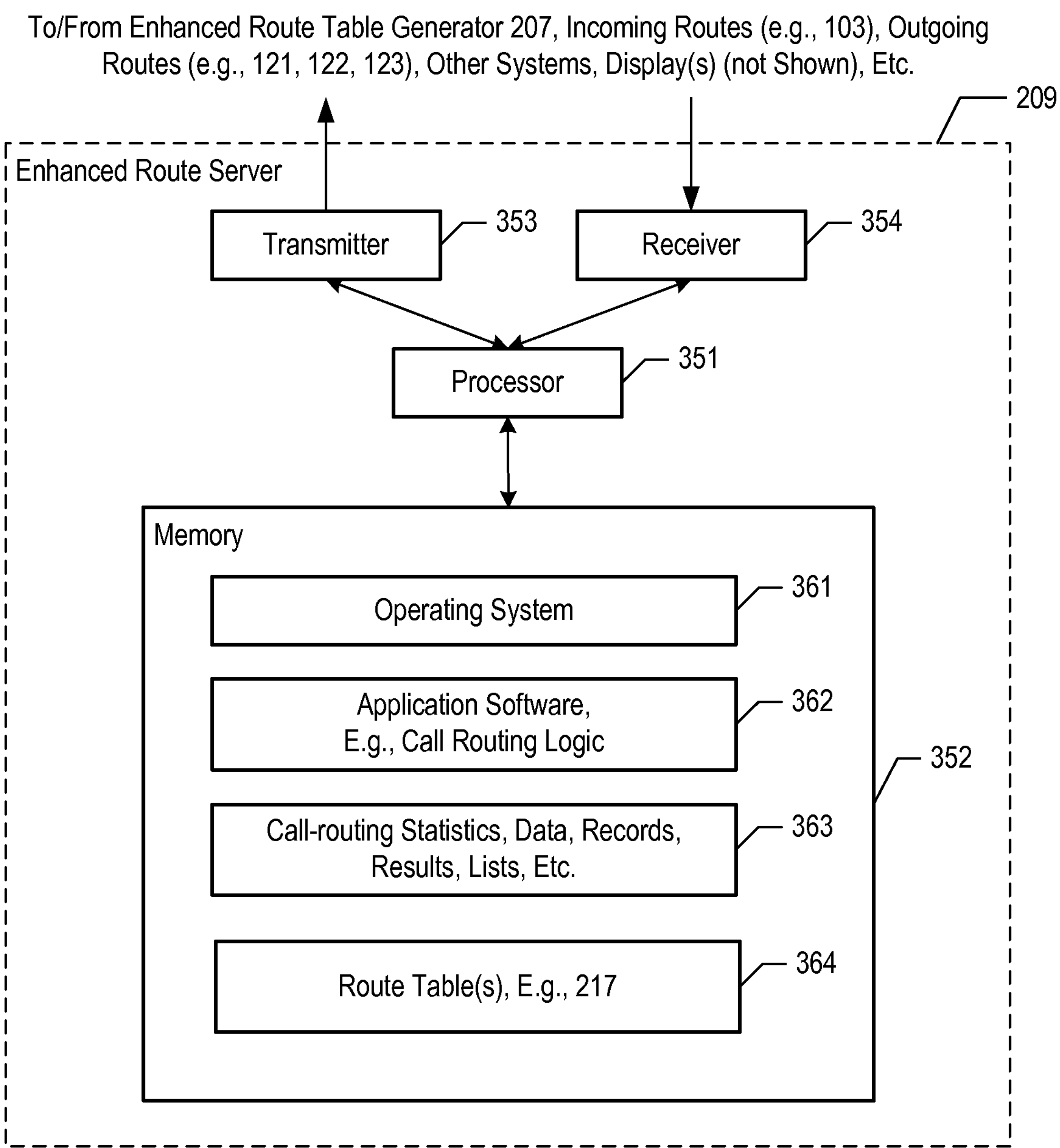

To/From Enhanced Route Table Generator 207, Incoming Routes (e.g., 103), Outgoing Routes (e.g., 121, 122, 123), Other Systems, Display(s) (not Shown), Etc.
209
Enhanced Route Server
Transmitter
353
Receiver
354
Processor
351
Memory
Operating System
361
Application Software, E.g., Call Routing Logic
362
352
Call-routing Statistics, Data, Records, Results, Lists, Etc.
363
Route Table(s), E.g., 217
364

Figure 4

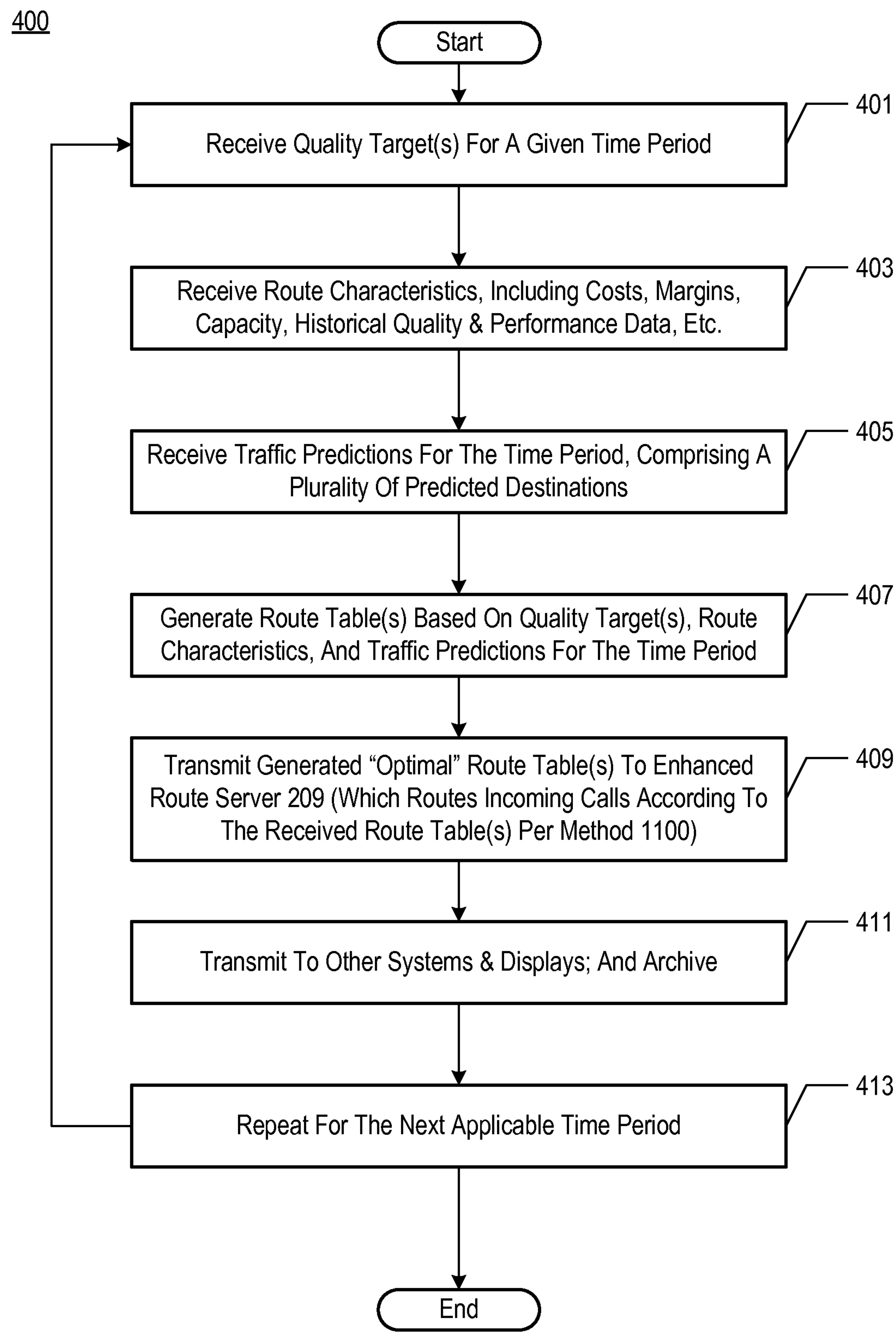

400
Start
Receive Quality Target(s) For A Given Time Period
401
Receive Route Characteristics, Including Costs, Margins, Capacity, Historical Quality & Performance Data, Etc.
403
Receive Traffic Predictions For The Time Period, Comprising A Plurality Of Predicted Destinations
405
Generate Route Table(s) Based On Quality Target(s), Route Characteristics, And Traffic Predictions For The Time Period
407
Transmit Generated "Optimal" Route Table(s) To Enhanced Route Server 209 (Which Routes Incoming Calls According To The Received Route Table(s) Per Method 1100)
409
Transmit To Other Systems & Displays; And Archive
411
Repeat For The Next Applicable Time Period
413
End

Figure 5

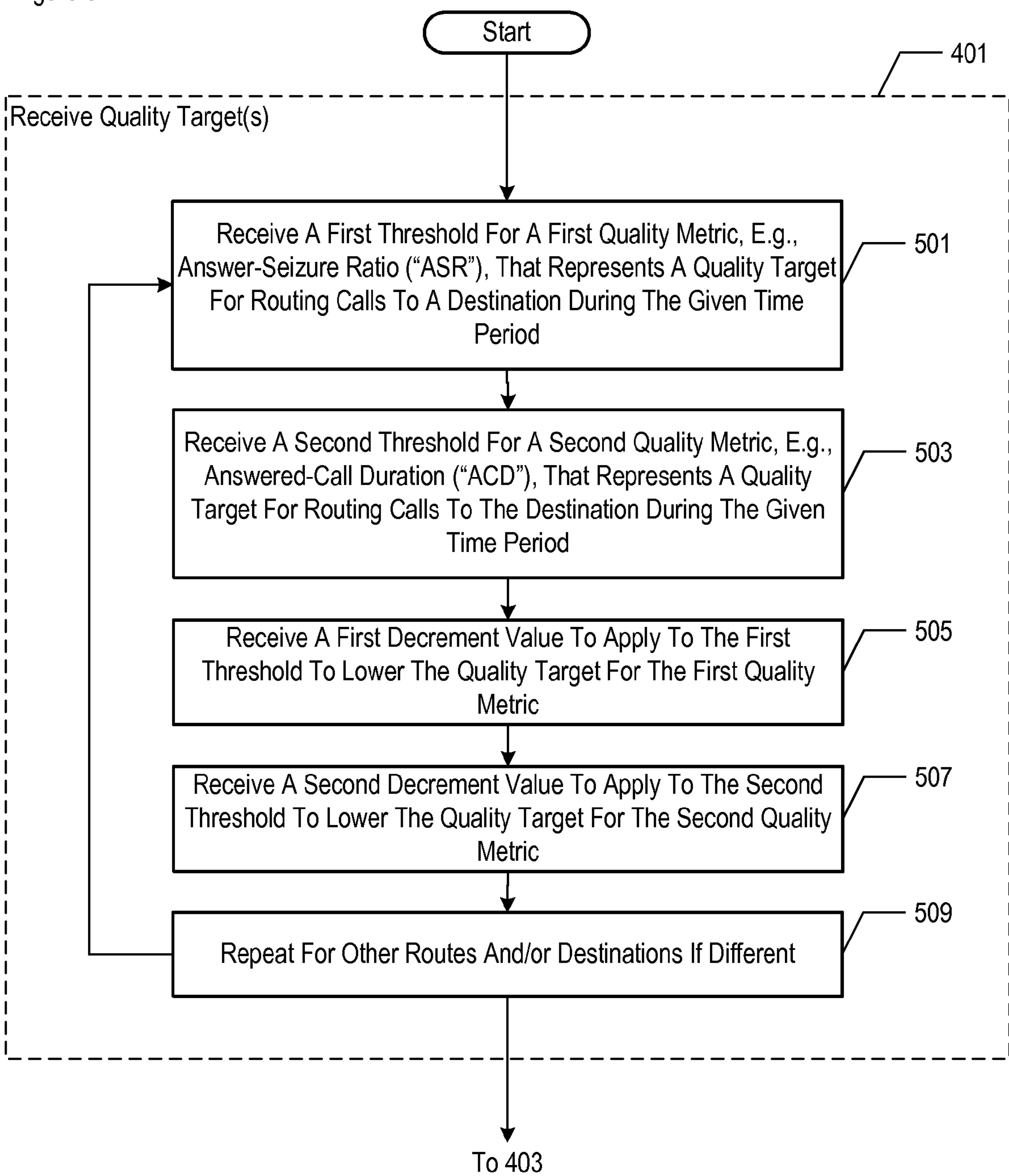

Start
401
Receive Quality Target(s)
Receive A First Threshold For A First Quality Metric, E.g., Answer-Seizure Ratio ("ASR"), That Represents A Quality Target For Routing Calls To A Destination During The Given Time Period
501
Receive A Second Threshold For A Second Quality Metric, E.g., Answered-Call Duration ("ACD"), That Represents A Quality Target For Routing Calls To The Destination During The Given Time Period
503
Receive A First Decrement Value To Apply To The First Threshold To Lower The Quality Target For The First Quality Metric
505
Receive A Second Decrement Value To Apply To The Second Threshold To Lower The Quality Target For The Second Quality Metric
507
Repeat For Other Routes And/or Destinations If Different
509
To 403

Figure 6

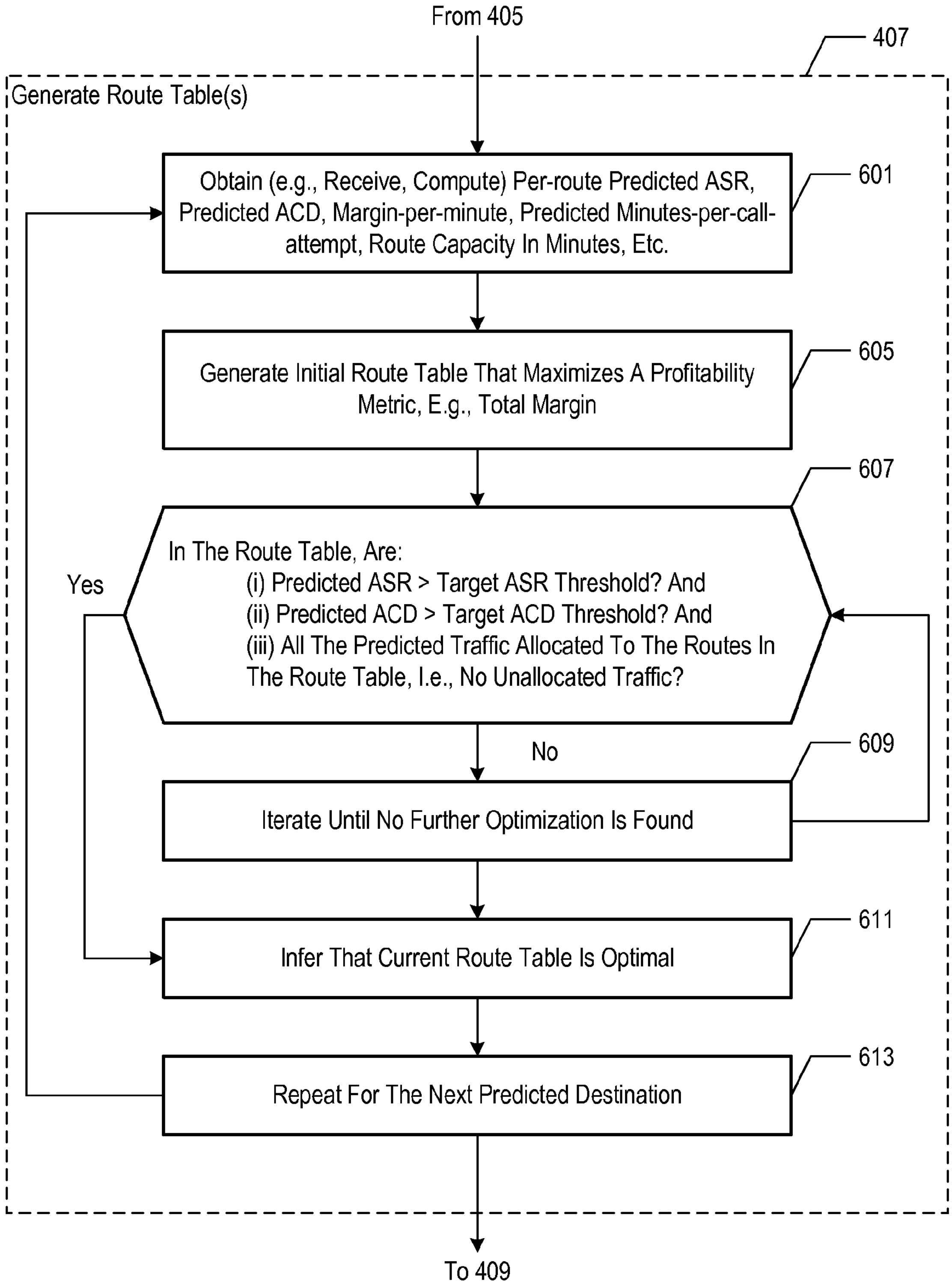

From 405
407
Generate Route Table(s)
Obtain (e.g., Receive, Compute) Per-route Predicted ASR, Predicted ACD, Margin-per-minute, Predicted Minutes-per-call-attempt, Route Capacity In Minutes, Etc.
601
Generate Initial Route Table That Maximizes A Profitability Metric, E.g., Total Margin
605
607
In The Route Table, Are:
(i) Predicted ASR > Target ASR Threshold? And
(ii) Predicted ACD > Target ACD Threshold? And
(iii) All The Predicted Traffic Allocated To The Routes In The Route Table, I.e., No Unallocated Traffic?
Yes
No
609
Iterate Until No Further Optimization Is Found
611
Infer That Current Route Table Is Optimal
613
Repeat For The Next Predicted Destination
To 409

Figure 7

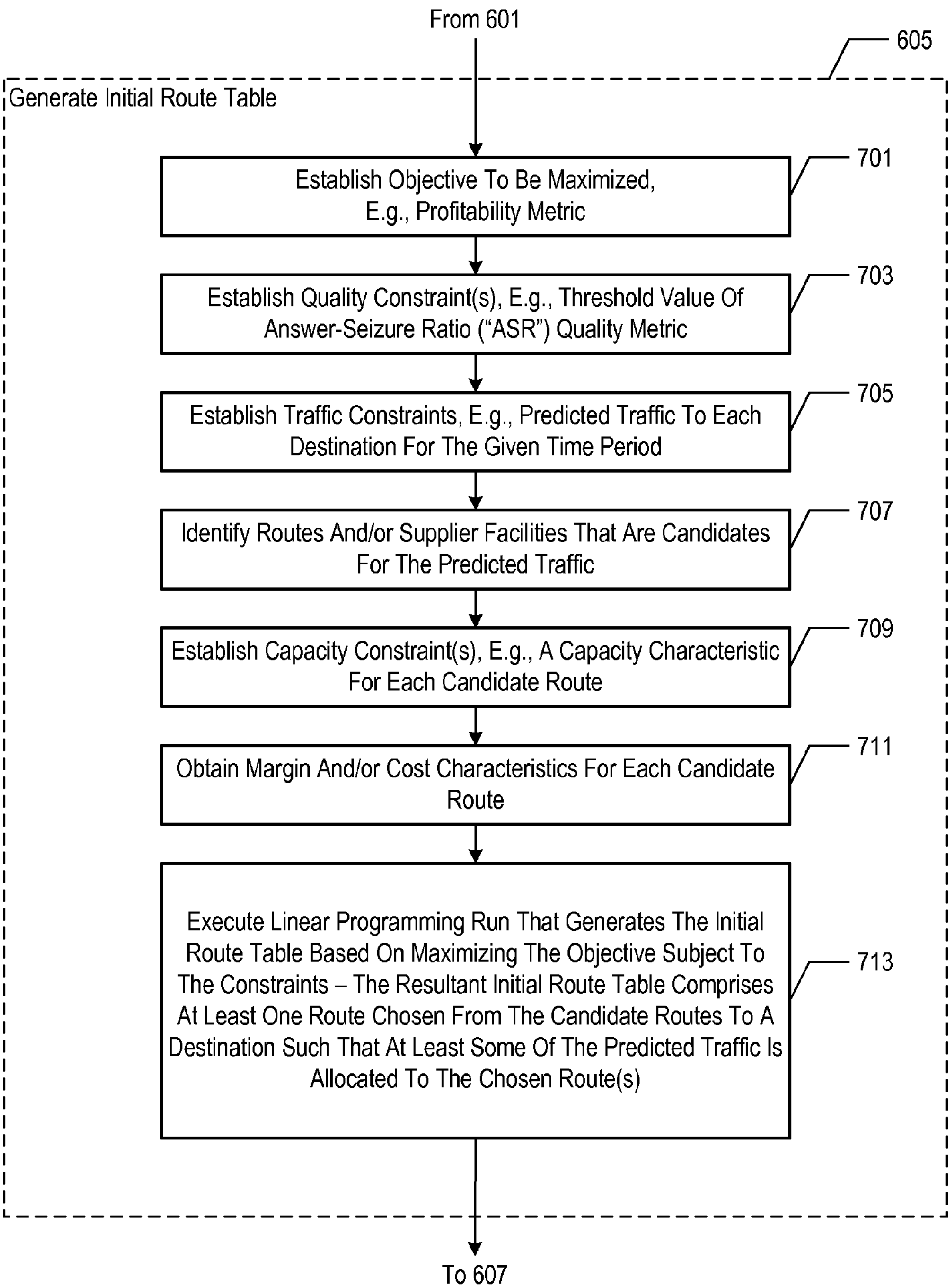

From 601
605
Generate Initial Route Table
Establish Objective To Be Maximized, E.g., Profitability Metric
701
Establish Quality Constraint(s), E.g., Threshold Value Of Answer-Seizure Ratio ("ASR") Quality Metric
703
Establish Traffic Constraints, E.g., Predicted Traffic To Each Destination For The Given Time Period
705
Identify Routes And/or Supplier Facilities That Are Candidates For The Predicted Traffic
707
Establish Capacity Constraint(s), E.g., A Capacity Characteristic For Each Candidate Route
709
Obtain Margin And/or Cost Characteristics For Each Candidate Route
711
Execute Linear Programming Run That Generates The Initial Route Table Based On Maximizing The Objective Subject To The Constraints – The Resultant Initial Route Table Comprises At Least One Route Chosen From The Candidate Routes To A Destination Such That At Least Some Of The Predicted Traffic Is Allocated To The Chosen Route(s)
713
To 607

Figure 8

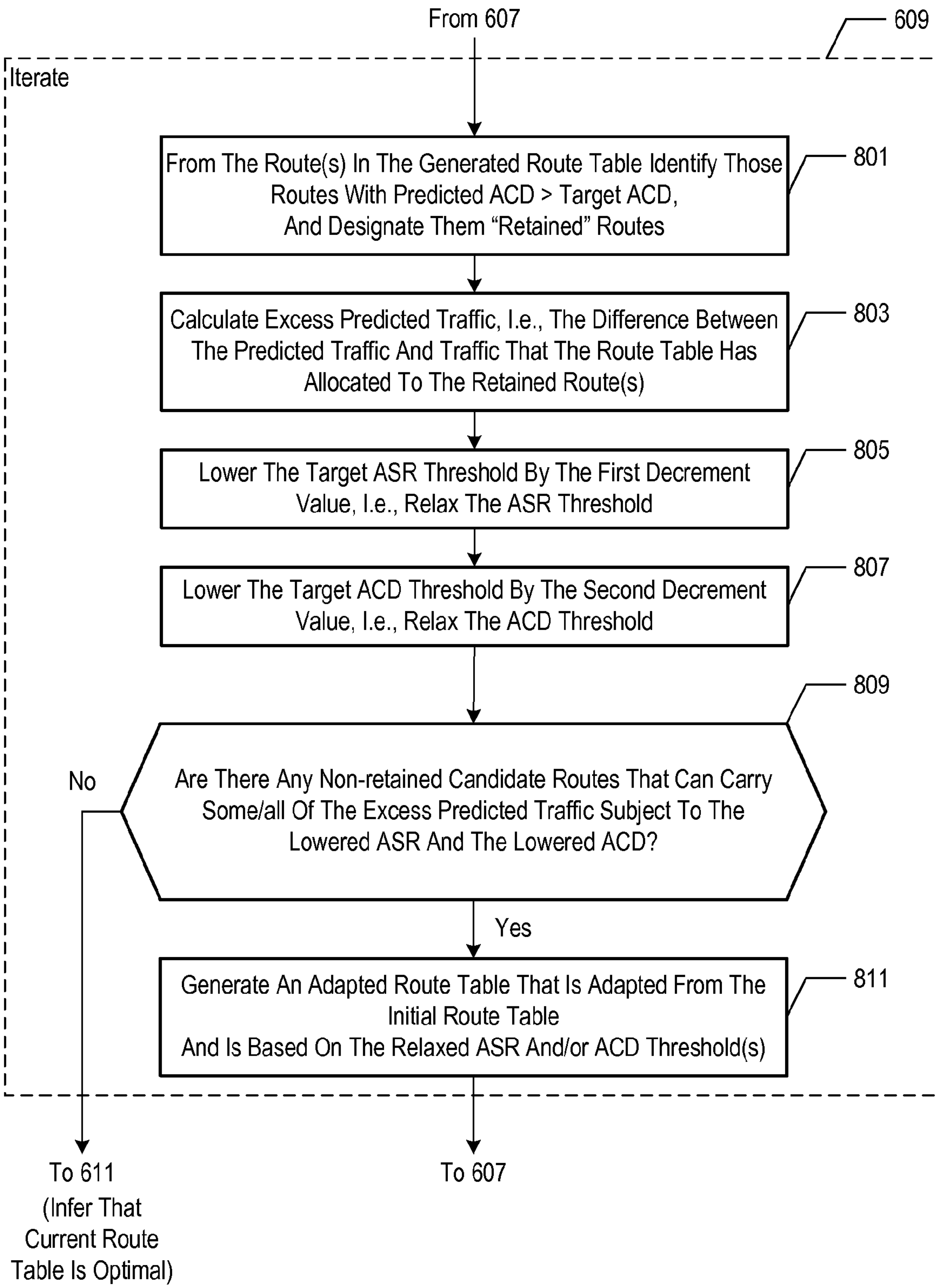
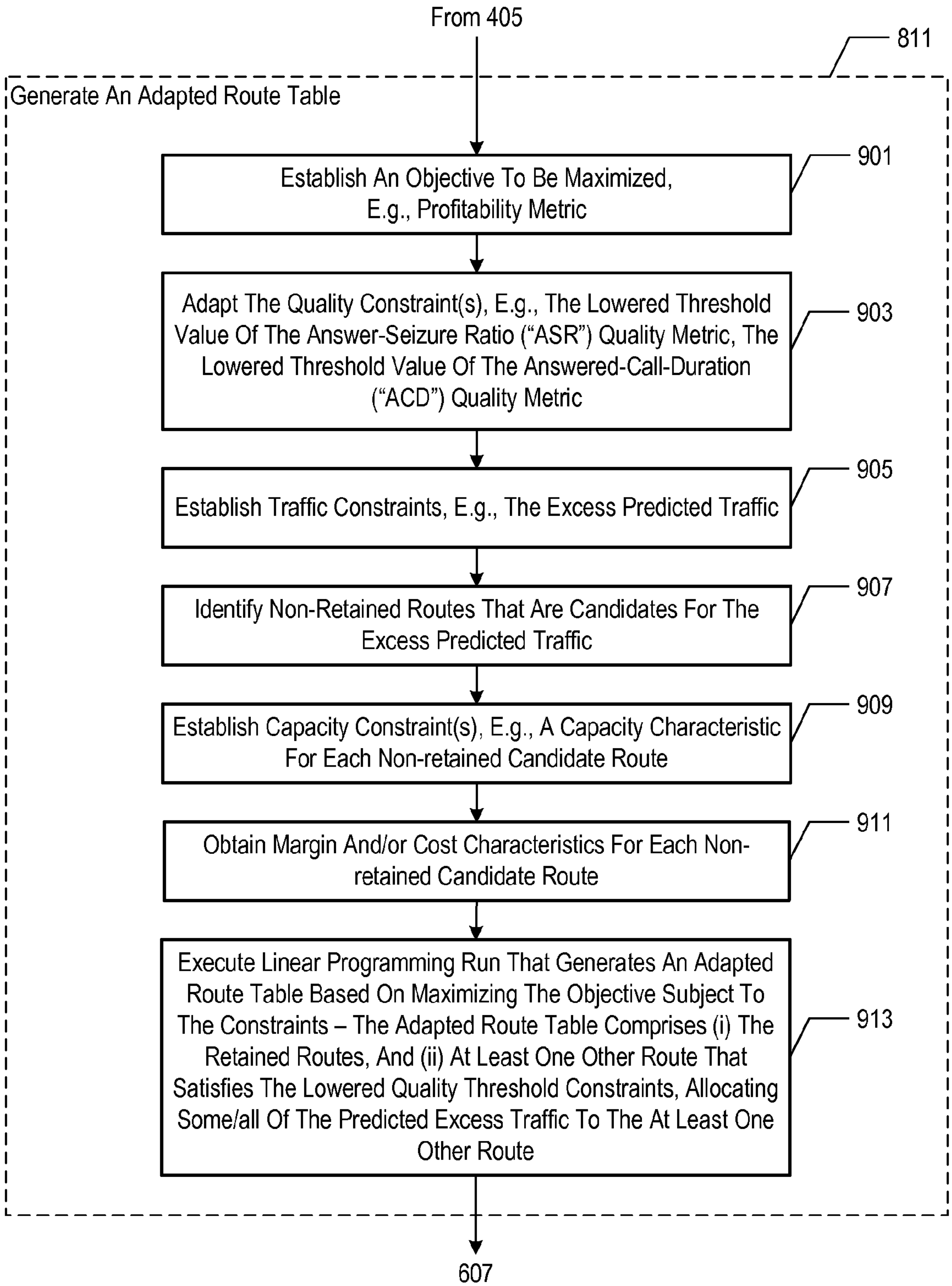

From 607
609
Iterate
From The Route(s) In The Generated Route Table Identify Those Routes With Predicted ACD > Target ACD, And Designate Them "Retained" Routes
801
Calculate Excess Predicted Traffic, I.e., The Difference Between The Predicted Traffic And Traffic That The Route Table Has Allocated To The Retained Route(s)
803
Lower The Target ASR Threshold By The First Decrement Value, I.e., Relax The ASR Threshold
805
Lower The Target ACD Threshold By The Second Decrement Value, I.e., Relax The ACD Threshold
807
Are There Any Non-retained Candidate Routes That Can Carry Some/all Of The Excess Predicted Traffic Subject To The Lowered ASR And The Lowered ACD?
809
No
Yes
Generate An Adapted Route Table That Is Adapted From The Initial Route Table And Is Based On The Relaxed ASR And/or ACD Threshold(s)
811
To 611 (Infer That Current Route Table Is Optimal)
To 607

Figure 9


From 405
811
Generate An Adapted Route Table
Establish An Objective To Be Maximized, E.g., Profitability Metric
901
Adapt The Quality Constraint(s), E.g., The Lowered Threshold Value Of The Answer-Seizure Ratio ("ASR") Quality Metric, The Lowered Threshold Value Of The Answered-Call-Duration ("ACD") Quality Metric
903
Establish Traffic Constraints, E.g., The Excess Predicted Traffic
905
Identify Non-Retained Routes That Are Candidates For The Excess Predicted Traffic
907
Establish Capacity Constraint(s), E.g., A Capacity Characteristic For Each Non-retained Candidate Route
909
Obtain Margin And/or Cost Characteristics For Each Non-retained Candidate Route
911
Execute Linear Programming Run That Generates An Adapted Route Table Based On Maximizing The Objective Subject To The Constraints – The Adapted Route Table Comprises (i) The Retained Routes, And (ii) At Least One Other Route That Satisfies The Lowered Quality Threshold Constraints, Allocating Some/all Of The Predicted Excess Traffic To The At Least One Other Route
913
607

Illustrative Initial Route Table
E.g., From Operation 605

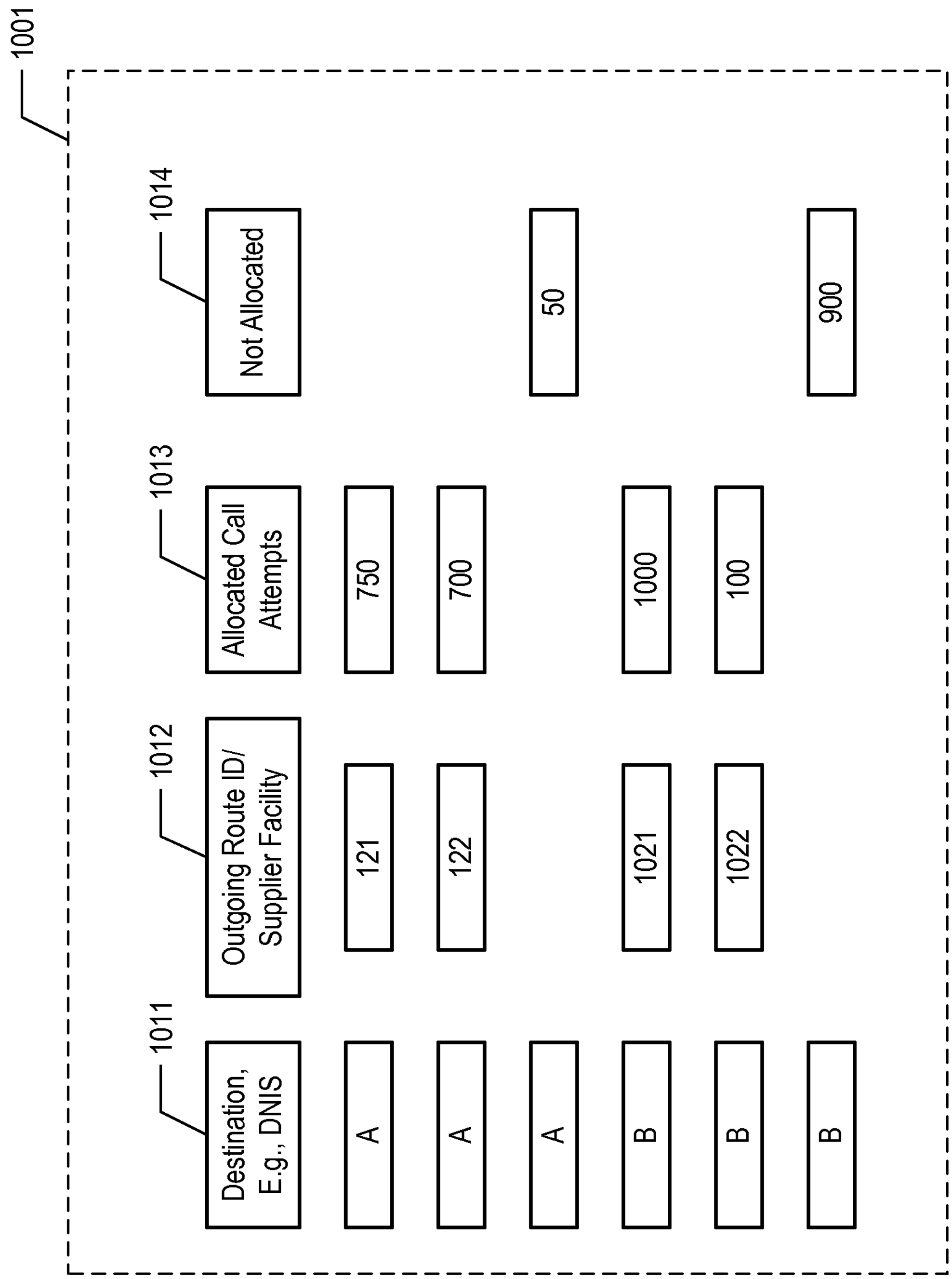


Figure 10A

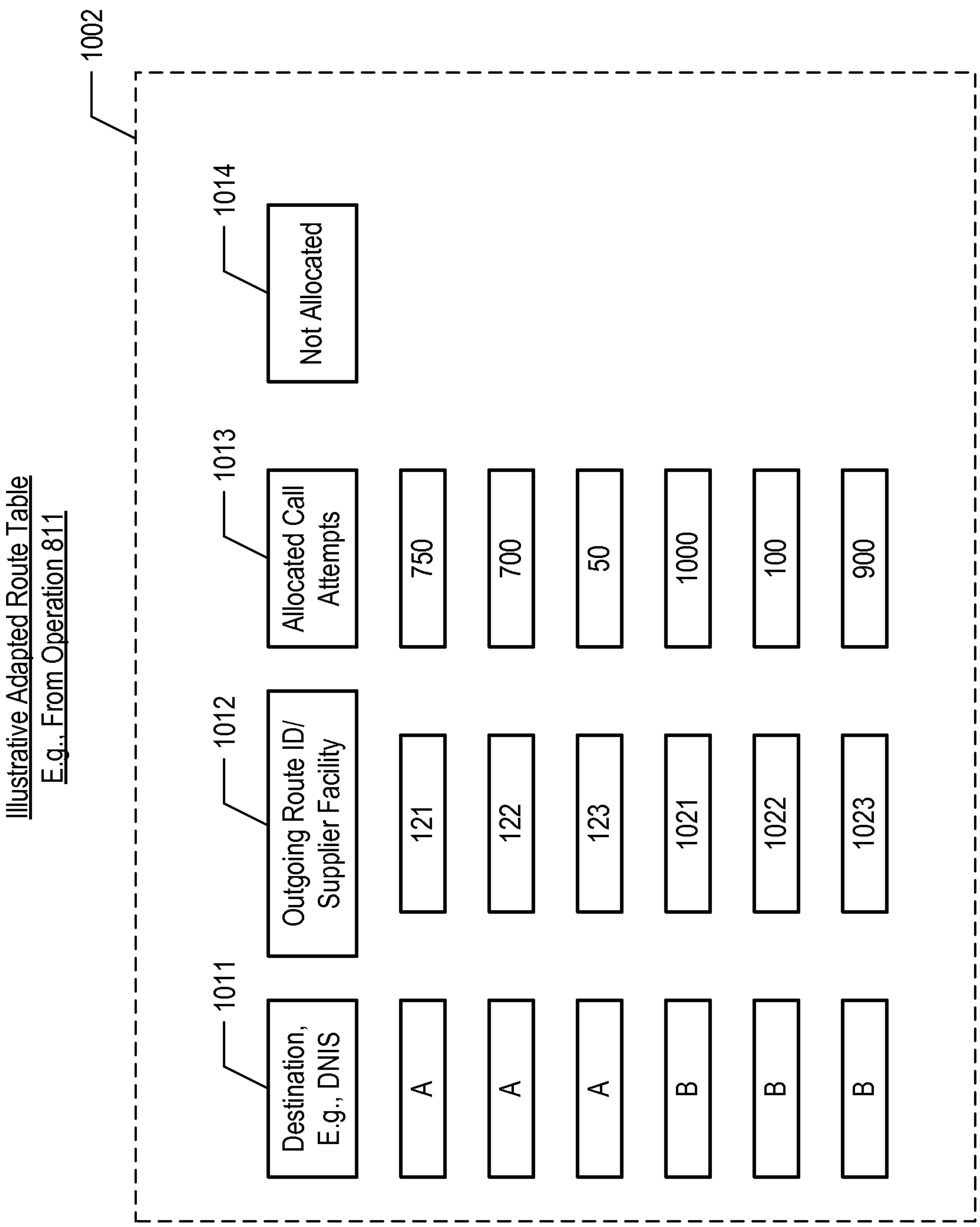
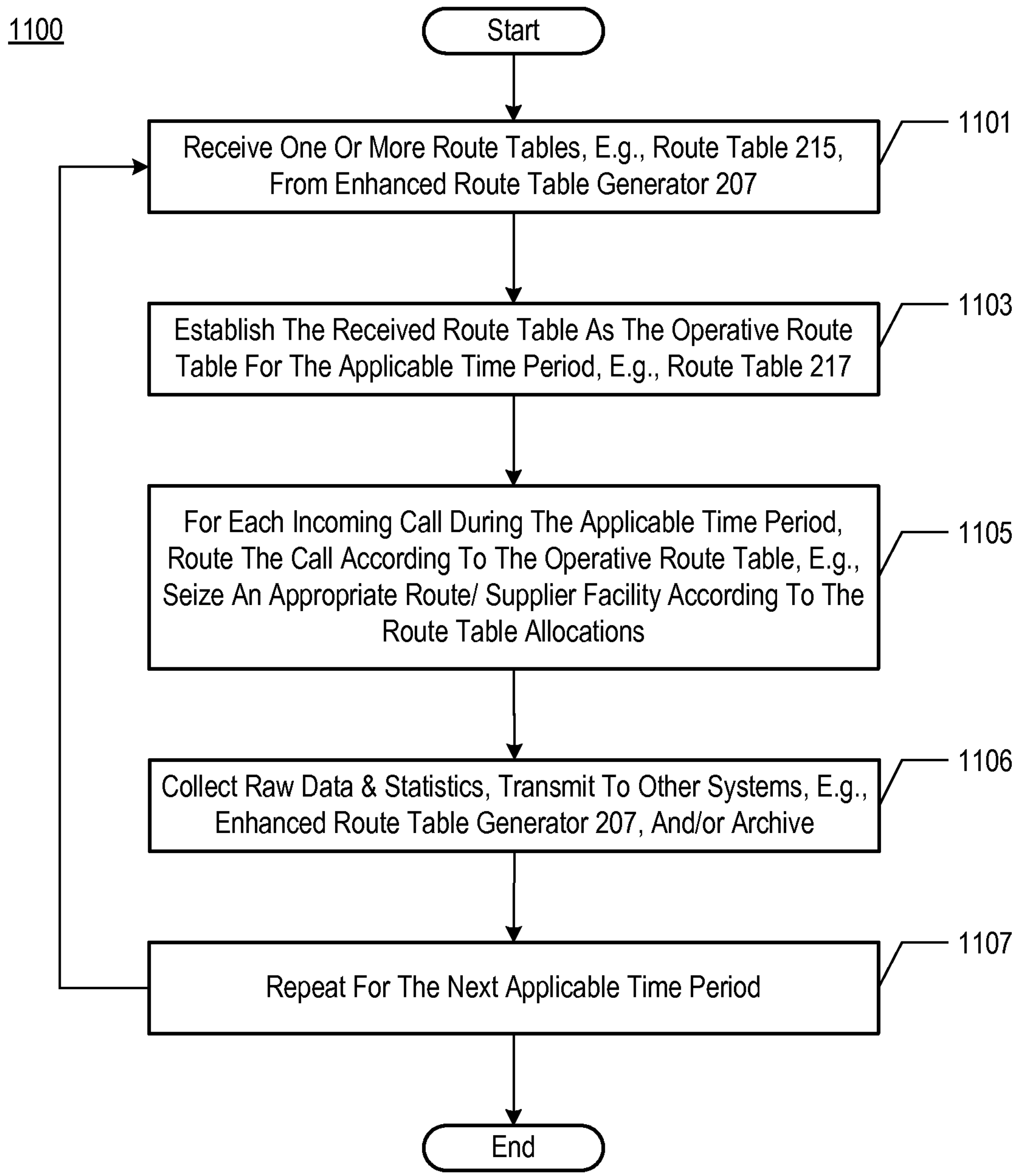

Illustrative Adapted Route Table
E.g., From Operation 811
1002
1011
Destination, E.g., DNIS
1012
Outgoing Route ID/ Supplier Facility
1013
Allocated Call Attempts
1014
Not Allocated
A
121
750
A
122
700
A
123
50
B
1021
1000
B
1022
100
B
1023
900

Figure 10B

Figure 11


1100
Start
Receive One Or More Route Tables, E.g., Route Table 215, From Enhanced Route Table Generator 207
1101
Establish The Received Route Table As The Operative Route Table For The Applicable Time Period, E.g., Route Table 217
1103
For Each Incoming Call During The Applicable Time Period, Route The Call According To The Operative Route Table, E.g., Seize An Appropriate Route/ Supplier Facility According To The Route Table Allocations
1105
Collect Raw Data & Statistics, Transmit To Other Systems, E.g., Enhanced Route Table Generator 207, And/or Archive
1106
Repeat For The Next Applicable Time Period
1107
End

SYSTEM AND METHOD FOR QUALITY AUTO-BLENDING IN CALL ROUTING

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a continuation of application Ser. No. 13/770,103, filed Feb. 19, 2013, incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to telecommunications in general, and, more particularly, to call routing analysis.

BACKGROUND OF THE INVENTION

FIG. **1**A depicts a schematic diagram of a portion of telecommunications system **100** that is typical in the prior art. Telecommunications system **100** comprises: a source of traffic predictions **105**, a source of route characteristics (or corresponding supplier facility characteristics) **106**, route table generator **107**, and route server **109**. FIG. **1**A additionally depicts: call origin **101**, incoming route **103**, outgoing routes **121**, **122**, and **123**, and call destination **113**, which are connected to telecommunications system **100** as shown, but which are not components of telecommunications system **100**.

Call origin **101**, which well known in the art, represents a point where a call is initiated such as a telephone, a mobile station, a computer, etc., without limitation.

Incoming route **103**, which is well known in the art, comprises one or more telecommunications facilities that collectively are capable of carrying a call (whether a voice call, a text message, or a data session) from call origin **101** to route server **109**, e.g., trunks, switches, networks, sub-networks, the U.S. public switched telephone network, a national telecommunications network, the Internet, etc. Incoming route **103** can be circuit-switched, packet-switched, or a combination thereof, without limitation.

Traffic predictions **105**, which are well known in the art, are stored in one or more data structures, and comprise predicted telecommunications traffic data for one or more periods of time, for one or more destinations. For example and without limitation, traffic predictions **105** comprise, per destination in a given period of time, the number of predicted calls. Traffic predictions **105** may be stored in a component of route table generator **107** or in a stand-alone component, or may be supplied by an outside system, or a combination thereof, etc., without limitation.

Route characteristics **106**, which are well known in the art, are stored in one or more data structures, and comprise information about any facilities and outgoing routes emanating from route server **109**. For example and without limitation, route characteristics **106** comprise the capacity of each available outgoing route and/or outgoing facility emanating from route server **109** typically measured in calling minutes available per hour; historical information about the routes/facilities, such as maintenance periods when a facility or route might be completely unavailable; and other historical performance data such as failure rates that measure the reliability of the route/facility. Route characteristics **106** may be stored in a component of route table generator **107** or in a stand-alone component, or may be supplied by an outside system, or a combination thereof, etc., without limitation.

Route table generator **107**, which is well known in the art, is based on a processor or data-processing system or other

computing platform. Route table generator **107** receives route characteristics **106** and traffic predictions **105** and, based on these and other data, generates one or more route tables for the use of route server **109**. Route table generator **107** is discussed in further detail in subsequent figures.

Route server **109**, which is well known in the art, is based on a processor, data-processing system, computing platform, call-processing system, or call-switching platform. Route server **109** may be co-resident with route table generator **107** or may be a separate component from route table generator **107**. Route server **109** receives calls via one or more incoming routes such as incoming route **103** and, based on the contents of the route table generated by route-table generator **107**, selects a proper outgoing facility and/or outgoing route for each call. Route server **109** is discussed in further detail in subsequent figures. According to the present figure, route server **109** is connected to three possible outgoing routes—routes **121**, **122**, and **123**—all of which lead to the same destination **113**.

Routes **121**, **122**, and **123**, which are well known in the art, each comprises one or more telecommunications facilities capable of carrying a call (whether a voice call, a text message, or a data session) from route server **109** to call destination **113** or to an intermediate destination, e.g., trunks, switches, networks, sub-networks, the U.S. public switched telephone network, a national telecommunications network, the Internet, etc. Outgoing routes **121**, **122**, and **123** each can be circuit-switched, packet-switched, or a combination thereof, without limitation.

Call destination **113**, which is well known in the art, represents a termination point where a call can be answered, such as a telephone, a mobile station, a computer, a switch, an answering machine, an incoming voice-response system, etc., without limitation. A destination **113** can be represented by any suitable addressing scheme such as a dialed number, a "Dialed Number Identification Service" ("DNIS"), a "Uniform Resource Locator" ("URL"), or a data endpoint address, a country code, or a city code, or an area code, or a combination thereof, etc., without limitation. Destination identification is well known in the art.

FIG. **1**B depicts a more detailed schematic diagram of a portion of prior-art telecommunications system **100** depicted in FIG. **1**A, including call **1**B being routed to and answered at destination **113**. In addition to the components and elements described in FIG. **1**A, FIG. **1**B additionally depicts: route table **115** in route table generator **107**, route table **117** in route server **109**, call **1**B originating at call origin **101**, a call attempt at the ingress to route server **109**, a call seizure at the egress from route server **109** via outgoing route **123**, and an answered call at destination **113**.

As shown here, route table generator **107** generates table **115**, which comprises only route **123** for destination **113** for the applicable time period. Route table generator **107** transmits route table **115** to route server **109**. Route server **109** receives route table **115** and establishes it as the operative route table **117** to be used during the applicable time period.

As shown here, call **1**B comes into route server **109** as a call attempt. Route server **109** receives call **1**B and applies route table **117**, which is the operative route table to be used during the present time period. According to route table **117**, route **123** is the only allowed route to be used during the present time period. Accordingly, route server **109** places call **1**B onto the telecommunications facilities corresponding to route **123**, sending call **1**B onwards towards destination **113**—this operation represents a call seizure.

As shown here, call **1**B successfully reaches destination **113**, where the call is answered. Accordingly, call **1**B is an answered call.

As shown here, outgoing route **123** is, among routes **121**, **122**, and **123**, the one with the maximum profitability margin, and hence the reason it is the sole route in route table **115/117**. This is because, according to the prior art, route table generator **107** generates route tables based on using maximum-margin routes; lower margin routes, which are less profitable, are not chosen for route table **115**. This scheme is advantageous to the operator of route server **109**, because it favors only the most profitable routes. However, as will become clear in FIG. **1**C below, this scheme also presents several disadvantages, because it can cause substantial call blocking when the maximum-margin route lacks sufficient capacity to carry all incoming call attempts.

FIG. **1**C depicts a more detailed schematic diagram of a portion of telecommunications system **100** depicted in FIG. **1**A, including call **1**C being blocked and not reaching destination **113**. In addition to the components and elements described in FIG. **1**A and FIG. **1**B, FIG. **1**C additionally depicts: call **1**C originating at call origin **101**, a call attempt at the ingress to route server **109**, route **123** lacking capacity to carry call **1**C, and consequently, call **1**C being blocked at the egress from route server **109**.

As shown earlier, table **115/117** comprises only route **123** for destination **113**.

As shown here, call **1**C comes into route server **109** as a call attempt. Route server **109** receives call **1**C and applies operative route table **117**; route **123** is the only allowed route to be used during the present time period according to route table **117**. However, the facilities of route **123** are not available to carry call **1**C (e.g., because the facilities are all busy with other calls or are down for maintenance, etc.). Route server **109** is constrained in only having route **123** populated in route table **117**, and when route **123** is not available, route server **109** blocks outgoing call **1**C. No call seizure occurs. The caller who originated call **1**C must try again.

As explained, blocked calls are a substantial disadvantage in this scheme. First, they result in caller dissatisfaction. Second, they cost the route server operator profits when calls go uncompleted or unexpectedly drop. Moreover, margin-maximizing schemes like the one described above fail to consider other routes that have lower profit margins but are still cost-competitive.

SUMMARY OF THE INVENTION

The present inventors devised certain quality considerations that are blended into generating a route table to overcome some of the disadvantages of the prior art. Because call blocking is disadvantageous, expanding the number of route choices would be desirable, but risks damaging the operator's profitability when the added routes are not cost-effective. On the other hand, lowest-cost routes sometimes are plagued by quality problems such as poor voice quality, unavailability, unreliability, dropped calls, etc. Thus, merely adding more lowest-cost routes will not address the problems that arise in the prior art. The present inventors devised a system and method for blending particular quality considerations into the process of expanding the route choices in a route table, such that more calls can be successfully routed while retaining the operator's objective of maximizing profitability. The disclosed quality auto-blending techniques evaluate candidate outgoing routes based on specific quality metrics to determine (i) whether a new route should be chosen for a route table and (ii) how call volumes are to be allocated among the chosen routes, so that overall profitability can be maximized within the governing constraints of quality targets, route quality, predicted traffic, and route capacity. It will be understood by those having ordinary skill in the art, after reading the present disclosure, that any reference herein to a route also includes any devices or facilities that carry traffic into and out of the disclosed route server.

An illustrative telecommunications system comprises an enhanced route table generator and an enhanced route server. The route table generator generates a route table that is to direct the route server how to route calls during a given period of time, e.g., during the upcoming hour. The route table generator transmits the route table to the route server. During the given time period, the route server routes incoming call attempts based on the route choices and call allocations specified in the route table.

The route table generator iteratively generates and adapts a route table until no further optimization can be found. In this iterative process, the route table generator maximizes a profitability objective while expanding the pool of suitable routes in the route table based in part on quality targets. Some routes in the route table are allocated larger call volumes while other routes are allocated lower call volumes based in part on the quality metrics that are defined herein:

- an "answer-seizure ratio" ("ASR") quality metric that is based on a ratio of answered calls to call seizures, and
- an "answered-call duration" ("ACD") quality metric that measures call duration per answered call for the given time period.

The answer-seizure ratio ASR represents a measure of quality of a route, because a call that is routed via an inadequate route may never reach its final destination and therefore cannot be answered at the destination. Thus a low ratio of answered calls to seized calls tends to indicate that the route has connection problems. The answered-call duration ACD represents a measure of quality of a route, because a call that is answered but has very poor voice quality, e.g., is unintelligible, has noise, has break-ups, etc., will not last long, because the parties on the call will get frustrated and hang up. Also, poor quality routes that drop calls also will have a short ACD. Thus, a short answered-call duration as compared to a baseline figure tends to indicate that the route has transmission problems.

The enhanced route table generator illustratively executes a linear programming run that generates an initial route table that maximizes a profitability metric for the predicted traffic for the given time period based at least in part on (i) a first threshold value of the ASR quality metric for the predicted traffic, wherein the ASR quality metric is based on a ratio of answered calls to call seizures, and (ii) the predicted traffic for the given time period. The resulting initial route table maximizes the objective subject to the established constraints and comprises at least one route chosen from the candidate routes such that at least some of the predicted traffic is allocated to the chosen route(s).

When the initial route table is evaluated against several criteria, including a target threshold value for the ACD quality metric, and is deemed not optimal by the route table generator, one or more linear programming runs are executed iteratively until an adapted route table is generated that is deemed optimal. In the course of the iterative route table generation, the ASR and ACD target thresholds are successively relaxed. Each route table generated in a subsequent linear programming run maximizes a profitability metric for the predicted traffic for the given time period based at least in part on (i) a relaxed threshold value of the ASR quality metric for the predicted traffic, wherein the ASR quality metric is based on a ratio of answered calls to call seizures, (ii) the predicted traffic for the given time period, and (iii) a relaxed threshold value of the ACD quality metric for the predicted traffic, wherein the ACD quality metric measures call duration per answered call for the given time period. In this way, the quality considerations are auto-blended into the route generation process, and they affect which routes are chosen and how big of a traffic allocation they are given so that profitability can be maximized to the extent possible. As a result, when calls are routed according to the optimized route table (whether it is the initial route table or a later adapted route table based on the initial route table), the resultant call routing is based on (A) the ASR quality metric and (B) the ACD quality metric.

An illustrative method comprises:

generating, by a telecommunications system, a route table for a predicted traffic, wherein the generating is based at least in part on:
- (i) a first threshold value of a first quality metric for the predicted traffic, wherein the first quality metric is based on a ratio of answered calls to call seizures, and
- (ii) the predicted traffic;

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from a plurality of routes that are candidates for carrying the predicted traffic; and

routing, by the telecommunications system, a plurality of calls according to the route table.

An illustrative system comprises:

a route table generator that is configured to generate a route table for a predicted traffic based at least in part on:
- (i) a first threshold value of a first quality metric for the predicted traffic, wherein the first quality metric is based on a ratio of answered calls to call seizures, and
- (ii) the predicted traffic; and

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from a plurality of routes that are candidates for carrying the predicted traffic; and

a route server that is configured to route a plurality of calls according to the route table.

Another illustrative method comprises:

receiving, by a route-table generator, a predicted traffic;

generating, by the route-table generator, a first route table for the predicted traffic, wherein the generating is based at least in part on:
- (i) a first threshold value of the first quality metric for the predicted traffic, wherein the first quality metric is based on a ratio of answered calls to call seizures, and
- (ii) a capacity characteristic for each of a plurality of routes that are candidates for carrying the predicted traffic, and
- (iii) the predicted traffic; and

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from the plurality of candidate routes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A depicts a schematic diagram of a portion of telecommunications system **100** that is typical in the prior art.

FIG. **1**B depicts a more detailed schematic diagram of a portion of telecommunications system **100** depicted in FIG. **1**A, including call **1**B being routed to and answered at destination **113**.

FIG. **1**C depicts a more detailed schematic diagram of a portion of telecommunications system **100** depicted in FIG. **1**A, including call **1**C being blocked and not reaching destination **113**.

FIG. **2**A depicts a schematic diagram of some salient elements of telecommunications system **200** according to an illustrative embodiment of the present invention, and illustrating call **2**A routed via route **121** and answered at destination **113**.

FIG. **2**B depicts a schematic diagram of some salient elements of telecommunications system **200** according to the illustrative embodiment of the present invention, and illustrating call **2**A routed via route **123** and answered at destination **113**.

FIG. **3**A depicts a schematic diagram of the hardware platform for enhanced route table generator **207** according to the illustrative embodiment.

FIG. **3**B depicts a schematic diagram of the hardware platform for enhanced route server **209** according to the illustrative embodiment.

FIG. **4** depicts some salient operations of method **400** according to the illustrative embodiment.

FIG. **5** depicts some salient sub-operations of operation **401** according to the illustrative embodiment.

FIG. **6** depicts some salient sub-operations of operation **407** according to the illustrative embodiment.

FIG. **7** depicts some salient sub-operations of operation **605** according to the illustrative embodiment.

FIG. **8** depicts some salient sub-operations of operation **609** according to the illustrative embodiment.

FIG. **9** depicts some salient sub-operations of operation **811** according to the illustrative embodiment.

FIG. **10**A depicts an illustrative initial route table **1001** generated according to operation **605** of the illustrative embodiment.

FIG. **10**B depicts an illustrative adapted route table **1002** generated according to operation **811** of the illustrative embodiment.

FIG. **11** depicts some salient operations of method **1100** according to the illustrative embodiment.

DETAILED DESCRIPTION

For the purposes of this specification, the following terms and their inflected forms are defined as follows:

1. A “call attempt” is defined as a call that arrives at a route server and which is to be processed by the route server. See, e.g., FIG. **1**B. Successful call attempts are routed to an outgoing route via an outgoing facility available at the route server; in contrast, failed call attempts are blocked at the route server.
2. A “call seizure” is defined as a successful processing of a call by a route server that seizes an outgoing facility and places the call onto the outgoing facility, which carries the call via an outgoing route; examples of outgoing facilities that can be seized include without limitation a telecommunications trunk, a network, a sub-network, or some other supplier facility, or a combination thereof, that is capable of carrying the call onwards from the route server to another destination, e.g., to the call’s final destination, or to an intermediate destination where the call is routed further. See, e.g., FIG. **1**B.
3. An “answered call” is defined as a call that has reached its final destination and that is answered, whether by a human or a machine, at the destination. See e.g., FIG.

1B. Once answered, an answered call has a duration typically measured in minutes.

4. A "blocked call" is defined a call attempt that is blocked at the route server when the route server does not seize any outgoing facility. Reasons for blocking the call include without limitation a lack of available facilities (e.g., all busy, down for maintenance, etc.), a lack of suitable facilities (e.g., no profit-bearing routes), a blockage enforced by a routing table in the route server, a failure in the route server, etc. See, e.g., FIG. **1**C.
5. A "answer-seizure ratio" ("ASR") is defined, according to the illustrative embodiment of the present invention, as a quality metric that is based on a ratio of answered calls to call seizures over a period of time.
6. A "answered-call duration" ("ACD") is defined, according to the illustrative embodiment of the present invention, as a quality metric that measures call duration per answered call over a period of time.

Other terms may be defined elsewhere in the present disclosure.

FIG. **2**A depicts a schematic diagram of some salient elements of telecommunications system **200** (with quality blending) according to an illustrative embodiment of the present invention, and depicts call **2**A routed via route **121** and answered at destination **113**. Telecommunications system **200** comprises: quality targets **201**, traffic predictions **205**, route characteristics **206**, enhanced route table generator **207** (comprising route table **215**), and enhanced route server **209** (comprising route table **217**). FIG. **2**A additionally depicts: call origin **101**, incoming route **103**, outgoing routes **121**, **122**, and **123**, and call destination **113**, which are connected to telecommunications system **200** as shown, but which are not components of telecommunications system **200** and which were described above and will not be repeated here for the sake of brevity.

FIG. **2**A further depicts: call **2**A originating at call origin **101**, a call attempt at the ingress to enhanced route server **209**, a call seizure at the egress from enhanced route server **209** via outgoing route **121**, and an answered call at destination **113**. FIG. **2**A also indicates that according to at least one relevant quality metric in respect to outgoing routes **121**, **122**, and **123**, the quality of route **121** exceeds the quality of route **122** which exceeds the quality of route **123**. Notably, these quality metrics were not considered in the prior-art schemes described in reference to FIGS. **1**A, **1**B, and **1**C. In contrast, the illustrative embodiment of the present invention takes into consideration one or more route-quality metrics when enhanced route table generator **207** generates route table **215**—the illustrative techniques are referred to herein as "quality blending" (or "quality auto-blending") and involve the ASR and ACD quality metrics. The quality metrics and quality blending techniques are described in more detail below and in the accompanying figures.

Quality targets **201** are stored in one or more data structures and comprise performance targets to be applied in generating route table **215**. According to the illustrative embodiment, quality targets **201** comprise (i) a first threshold for the answer-seizure ratio quality metric ("ASR"), and (ii) a second threshold for the answered-call duration quality metric ("ACD"). The quality targets **201** reflect aspirational levels of call-routing performance for a given time interval and will be discussed in more detail below and in the accompanying figures. According to the illustrative embodiment, quality targets **201** are stored in a data structure of a component external to enhanced route table generator **207**; however, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein quality targets **201** are stored within enhanced route table generator **207**, etc., without limitation.

Traffic predictions **205**, which are well known in the art, are stored in one or more data structures and comprise predicted telecommunications traffic data for one or more periods of time, for one or more destinations. For example and without limitation, traffic predictions **205** comprise, per destination in a given period of time, the number of predicted calls and the expected per-call duration. Notably, a feedback path (not shown) from enhanced route server **209** provides historical call duration information for traffic predictions **205**. According to the illustrative embodiment, traffic predictions **205** are generated and stored in a data structure of a component external to enhanced route table generator **207**; however, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein traffic predictions **205** are stored within enhanced route table generator **207**, etc., without limitation.

Route characteristics **206**, which are well known in the art, are stored in one or more data structures, and comprise information about any facilities and outgoing routes emanating from enhanced route server **209**, e.g., routes **121**, **122**, and **123**. For example and without limitation, route characteristics **206** comprise: the capacity of each outgoing route and/or outgoing facility emanating from enhanced route server **209** typically measured in calling minutes available per hour; historical information about the routes/facilities, such as maintenance periods when a facility or route might be completely unavailable; and other historical performance data such as failure rates that measure the reliability of the route/facility. Notably, a feedback path (not shown) from enhanced route server **209** provides historical information to route characteristics **206**. According to the illustrative embodiment, route characteristics **206** are generated and stored in a data structure of a component external to enhanced route table generator **207**; however, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein route characteristics **206** are stored within enhanced route table generator **207**, etc., without limitation.

Enhanced route table generator **207** (or "table generator **207**"), coordinates and executes the operations of method **400** herein, and is described in further detail below and in the accompanying figures.

Enhanced route server **209** (or "route server **209**"), coordinates and executes the operations of method **1100** herein, and is described in more detail below and in the accompanying figures. Notably, route server **209** is responsible for handling a call, i.e., processing a call arriving from an incoming route and placing it on an available outgoing route or corresponding facility (if any), but route server **209** is not responsible for handling the call after egress from the route server.

Route table **215**/**217** comprises routes **121**, **122**, and **123** for destination **113**; however, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein the route table comprises any number of outgoing routes according to the disclosed methods herein.

According to the illustrative embodiment, enhanced route table generator **207** and enhanced route server **209** are distinct components of telecommunications system **200**. However, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments of the present invention, wherein enhanced route table generator **207** and enhanced route server **209** are co-resident on the same hardware platform, or form a single integrated component, or are otherwise combined. It will be further clear to those having ordinary skill in the art, after reading the present disclosure, how to make alternative embodiments wherein elements **201**, **206**, **205**, **207**, and **209** are embodied in a single multi-functional integral component, or are differently combined or sub-divided than shown herein. Although the present figure depicts only one call origin **101**, one incoming call 2A, and one incoming route **103**, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make alternative embodiments of telecommunications system **200** with any number of call origins, any number of incoming call attempts, and any number of incoming routes. Likewise, although the present figure depicts only three outgoing routes and only one destination **113**, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make alternative embodiments of telecommunications system **200** with any number of outgoing routes and any number of destinations. Further, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make alternative embodiments wherein the relative quality of the outgoing routes is different than depicted here.

FIG. **2**B depicts a schematic diagram of some salient elements of telecommunications system **200** (with quality blending) according to the illustrative embodiment of the present invention, and illustrating call **2**A routed via route **123** and answered at destination **113**. FIG. **2**B depicts the same elements depicted in FIG. **2**A, except that outgoing routes **121** and **122** are unavailable here (e.g., all busy, down for maintenance, etc.) and call **2**B is routed by enhanced route server **209** to outgoing route **123**. Notably, although illustratively the quality (according to the ASR and/or ACD quality metrics) of route **123** is lower than the respective quality of the unavailable routes **121** and **122**, route table **217** includes route **123** and therefore call **2**B is not blocked.

FIG. **3**A depicts a schematic diagram of the hardware platform for enhanced route table generator **207** according to the illustrative embodiment. According to the illustrative embodiment, enhanced route table generator **207** is based on a data-processing apparatus whose hardware platform comprises: processor **301**, memory **302**, transmitter **303** and receiver **304**.

Processor **301** is a processing device such as a microprocessor that is well known in the art. Processor **301** is configured such that, when operating in conjunction with the other components of route table generator **207**, processor **301** executes software, processes data, and telecommunicates according to the operations described herein.

Memory **302** is non transitory and non volatile computer storage memory technology that is well known in the art, e.g., flash, RAM, etc. Memory **302** stores operating system **311**, application software **312**, element **313**, and element **314**. The specialized application software **312** that is executed by processor **301** is illustratively denominated the "quality autoblend logic" that enables enhanced route table generator **207** to perform the operations of method **400**. Memory element **313** illustratively comprises received quality targets (e.g., from quality targets **201**), traffic predictions (e.g., from traffic predictions **205**), route characteristics and historical performance data (e.g., from route characteristics **206**). Memory element **313** also comprises other data, records, results, lists, associations, indicators, whether of an intermediate nature, final results, or archival. The generated routing table(s) (e.g., route table **215**) that is to be transmitted to enhanced route server **209** is illustratively stored in memory element **314**. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one memory **302**; or comprise subdivided segments of memory **302**; or comprise a plurality of memory technologies that collectively store operating system **311**, application software **312**, and elements **313** and **314**.

Transmitter **303** is a component that enables route table generator **207** to telecommunicate with other components and systems by transmitting electromagnetic signals thereto. For example, transmitter **303** enables telecommunication pathways to quality targets **201**, traffic predictions **205**, route characteristics **206**, enhanced route server **209**, other systems (not shown), display(s) (not shown), etc. without limitation. Transmitter **303** is well known in the art. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one transmitter **303**. Transmitter **303** is shown in a wired configuration, but in some alternative embodiments, transmitter **303** may telecommunicate wirelessly.

Receiver **304** is a component that enables route table generator **207** to telecommunicate with other components and systems by receiving electromagnetic signals therefrom. For example, receiver **304** enables telecommunication pathways from quality targets **201**, traffic predictions **205**, route characteristics **206**, enhanced route server **209**, other systems (not shown), display(s) (not shown), etc. without limitation. Receiver **304** is well known in the art. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one receiver **304**. Receiver **304** is shown in a wired configuration, but in some alternative embodiments, receiver **304** may telecommunicate wirelessly.

It will be clear to those skilled in the art, after reading the present disclosure, that in some alternative embodiments the hardware platform of route table generator **207** can be embodied as a multi-processor platform, as a sub-component of a larger computing platform, as a virtual computing element, or in some other computing environment—all within the scope of the present invention. It will be clear to those skilled in the art, after reading the present disclosure, how to make and use the hardware platform for route table generator **207**.

FIG. **3**B depicts a schematic diagram of the hardware platform for enhanced route server **209** according to the illustrative embodiment. According to the illustrative embodiment, enhanced route server **209** is a data-processing apparatus whose hardware platform comprises: processor **351**, memory **352**, transmitter **353** and receiver **354**.

Processor **351** is a processing device such as a microprocessor that is well known in the art. Processor **351** is configured such that, when operating in conjunction with the other components of route server **209**, processor **351** executes software, processes data (including the processing of calls), and telecommunicates according to the operations described herein.

Memory **352** is non transitory and non volatile computer storage memory technology that is well known in the art, e.g., flash, RAM, etc. Memory **352** stores operating system **361**, application software **362**, element **363**, and element **364**. The specialized application software **362** that is executed by processor **351** is illustratively denominated the "call routing logic" that enables route server **209** to perform the operations of method **1100**. Memory element **363** illustratively comprises call routing statistics collected by route server **209**, as well as other data, records, results, lists, associations, indicators, whether of an intermediate nature, final results, or archival. The operative routing table(s) (e.g., route table **217**) that is the basis for routing calls is illustratively stored in memory element **364**. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one memory **352**; or comprise subdivided segments of memory **352**; or comprise a plurality of memory technologies that collectively store operating system **361**, application software **362**, and elements **363** and **364**.

Transmitter **353** is a component that enables route server **209** to telecommunicate with other components and systems by transmitting electromagnetic signals thereto. For example, transmitter **303** enables telecommunication pathways to enhanced route table generator **207**, incoming routes (e.g., **103**), outgoing routes (e.g., **121**, **122**, **123**), other systems (not shown), display(s) (not shown), etc. without limitation. Transmitter **353** is well known in the art. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one transmitter **353**. Transmitter **353** is shown in a wired configuration, but in some alternative embodiments, transmitter **353** may telecommunicate wirelessly.

Receiver **354** is a component that enables route server **209** to telecommunicate with other components and systems by receiving electromagnetic signals therefrom. For example, receiver **354** enables telecommunication pathways from enhanced route table generator **207**, incoming routes (e.g., **103**), outgoing routes (e.g., **121**, **122**, **123**), other systems (not shown), display(s) (not shown), etc. without limitation. Receiver **354** is well known in the art. It will be clear to those having ordinary skill in the art how to make and use alternative embodiments that comprise more than one receiver **354**. Receiver **354** is shown in a wired configuration, but in some alternative embodiments, receiver **354** may telecommunicate wirelessly.

It will be clear to those skilled in the art, after reading the present disclosure, that in some alternative embodiments the hardware platform of route server **209** can be embodied as a multi-processor platform, as a sub-component of a larger computing platform, as a virtual computing element, or in some other computing environment—all within the scope of the present invention. It will be clear to those skilled in the art, after reading the present disclosure, how to make and use the hardware platform for route server **209**.

FIG. **4** depicts some salient operations of method **400** according to the illustrative embodiment. Route table generator **207** is the entity within illustrative telecommunications system **200** that executes and coordinates the operations of method **400** according to the illustrative embodiment of the quality auto-blend logic.

At operation **401**, route table generator **207** receives one or more quality targets for a given time period, e.g., for the upcoming hour. Operation **401** is described in more detail below and in the accompanying figures.

At operation **403**, route table generator **207** receives route characteristics that include illustratively costs, margins, capacity, historical data, and performance data for each route that emanates from route server **209**. Illustratively, route table generator **207** receives route characteristics **206**. The routes that emanate from route server **209** that are potential candidates for routing a call to a given destination are designated herein as "candidate" routes. As described in more detail below, candidate routes are evaluated in subsequent operations and some are chosen for the route table.

At operation **405**, route table generator **207** receives traffic predictions for the given time period. The traffic predictions illustratively comprise traffic corresponding to a plurality of destinations that are served by telecommunications system **200**. Illustratively, route table generator **207** receives traffic predictions **205** for the given time period.

At operation **407**, route table generator **207** generates one or more route tables based on the quality targets, the route characteristics, and traffic predictions received in the preceding operations. Operation **407** is described in more detail below and in the accompanying figures.

At operation **409**, route table generator **207** transmits the generated route table(s) (designated "optimal") to route server **209**. As described in regard to method **1100**, route server **209** routes incoming calls according to the route table(s) received from route table generator **207**.

At operation **411**, route table generator **207** transmits information to other systems, and to any relevant displays, and archives as appropriate—according to transmission techniques that are well known in the art.

At operation **413**, route table generator **207** passes control back to operation **401** to repeat the aforementioned operations for the next applicable time period, e.g., the hour that follows the present given time period. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments of the present invention wherein method **400** is not limited to an upcoming fixed time period, but is instead executed in real-time to identify an "optimal" route or route table that is to be immediately applied to a pending call, such that the repetitive loop illustrated by operation **413** is eliminated in whole or in part. The present invention is not limited to an hourly or periodic execution of method **400** in preparation for an upcoming time period; a more flexible approach could be implemented by those having ordinary skill in the art, after reading the present disclosure.

In regard to method **400**, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments of method **400** wherein the recited operations and sub-operations are differently sequenced, grouped, or sub-divided—all within the scope of the present invention. It will be further clear to those skilled in the art, after reading the present disclosure, how to make and use alternative embodiments of method **400** wherein some of the recited operations and sub-operations are optional, are omitted, or are executed by other elements and/or systems, e.g., by route server **209** or by a unified element that both generates the route tables and routes call according thereto.

FIG. **5** depicts some salient sub-operations of operation **401** according to the illustrative embodiment.

At operation **501**, route table generator **207** receives a first threshold for a first quality metric, e.g., for the answer-seizure ratio ASR metric; the threshold represents a quality target for routing calls to a destination during the given time period. Illustratively, the target ASR threshold is 100%, meaning that the target is to have 100% of seized calls reach their destination and be answered.

At operation, **503**, route table generator **207** receives a second threshold for a second quality metric, e.g., for the answered-call duration ACD metric; the threshold represents a quality target for routing calls to the destination during the given time period. Illustratively, the target ACD threshold is 10 minutes, meaning that the target is to have a 10-minute call duration per call routed during the given time period.

At operation **505**, route table generator **207** receives a first decrement value to apply to the first threshold to lower (or relax) the quality target for the first quality metric. Illustratively, the first decrement is 10%, meaning that if it becomes necessary to relax the ASR target (as described in further detail below), the decrease will be in 10% decrements, i.e., from 100% ASR to 90% ASR to 81% ASR, etc.

At operation **507**, route table generator **207** receives a second decrement value to apply to the second threshold to lower (or relax) the quality target for the second quality metric. Illustratively, the second threshold is also 10%, meaning that if it becomes necessary to relax the ACD target (as described in further detail below), the decrease will be in 10% decrements, i.e., from 10 minutes-per-call ACD to 9 minutes to 8.1 minutes, etc.

At operation **509**, route table generator **207** passes control back to operation **501** to repeat the aforementioned operations for another destination having predicted traffic, or for other outgoing routes, as appropriate. When all destinations and outgoing routes associated with route server **209** have been considered, control passes to operation **403**. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and build alternative embodiments having different target values, different thresholds, different decrements, and different relaxation schemes from those of the illustrative embodiment.

FIG. **6** depicts some salient sub-operations of operation **407** according to the illustrative embodiment.

At operation **601**, route table generator **207** obtains (for example, by receiving from another entity, or by computing locally) a predicted ASR value for each candidate route. Illustratively, route table generator **207** computes a predicted ASR value for each candidate route based on historical data and performance metrics from earlier time periods, e.g., a baseline same hour of the day on the same year-ago day of week as the given period of time. Thus, for the relevant baseline time period on a given candidate route, route table generator **207** computes the ratio of answered calls to seized calls. This value is used as the predicted ASR. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments based on one or more of the following baseline time periods: last-hour today, same-hour yesterday, same-hour in previous one or more weeks, special days such as Mother's Day, etc. without limitations. The choice of an appropriate baseline time period is left to the implementers practicing the present invention.

Further, route table generator **207** also obtains a predicted ACD value for each candidate route, a predicted minutes-per-call-attempt value for each candidate route, and a capacity value for each candidate route (illustratively in minutes available for the given period of time). Illustratively, route table generator **207** computes the predicted ACD for each candidate route based on historical data and performance metrics from earlier time periods, e.g., a baseline same hour of the day on the same year-ago day of week as the given period of time. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments based on one or more of the following baseline time periods: last-hour today, same-hour yesterday, same-hour in past weeks, special days such as Mother's Day, etc. without limitations. The choice of an appropriate baseline time period is left to the implementers practicing the present invention.

Further, route table generator **207** also obtains a predicted minutes-per-call-attempt value for each candidate route. Illustratively, route table generator **207** computes the predicted minutes-per-call-attempt value for each candidate route based on historical data, measuring the ratio of the number of minutes a call was connected on the route to the number of call attempts during the baseline time period. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments based on one or more of the following baseline historical time periods: last-hour today, same-hour yesterday, same-hour in past weeks, special days such as Mother's Day, etc. without limitations. The choice of an appropriate baseline time period is left to the implementers practicing the present invention.

Further, route table generator **207** also obtains a capacity value for each candidate route, illustratively in minutes available for the given period of time.

It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to properly select the baseline figures and time periods to be used in computing the predicted metrics in the current operation. For example, for a given one-hour period of time, the baseline is illustratively the same hour of the day on the same year-ago day of week as the given period of time. However, other schemes could be devised, such as a daily hourly average from the previous day, or year-ago data that is modulated by a recent performance improvement in the facilities of a given route, etc. As noted earlier, it will be up to the implementers to choose one or more baseline time periods and supporting baseline data for obtaining the metrics specified in the present operation.

At operation **605**, route table generator **207** generates an initial route table that maximizes a predefined profitability metric. Illustratively, the profitability metric to be optimized is a total margin value encompassing all the allocated calls during the given time period according to the route table. Illustratively, route table generator **207** uses linear programming to process several constraints and maximize the total margin. The present operation is described in more detail below and in the accompanying figures.

At operation **607**, route table generator **207** analyzes whether, according to the generated route table:

(i) the predicted ASR exceeds the target ASR for every route in the route table, and

(ii) the predicted ACD exceeds the target ACD for every route in the route table, and

(iii) all the predicted traffic for the time period is allocated to the routes in the route table, i.e., there is no unallocated traffic in the route table.

When the answer to all three of these analyses is affirmative, control passes to operation **611**. When the answer to one or more of these analyses is negative, control passes to operation **609**.

At operation **609**, route table generator **207** iterates until no further route table optimization is found. When no further optimization is found, control passes to operation **611**; otherwise, control passes back to operation **607**. Operation **609** is described in further detail below and in the accompanying figures.

At operation **611**, which is reached from operation **607** and from operation **609**, route table generator **207** infers that the current extant route table is optimal and passes control to operation **613**.

At operation **613**, route table generator **207** repeats the cycle of operations for a next predicted destination for the given period of time; thus, for example, if the traffic predictions **205** predict traffic to ten distinct destinations for the given time period, operation **407** including its constituent sub-operations is executed for each of the ten distinct destinations. Then, control passes from operation **407** to operation **409**. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments of the present invention wherein operation **407** is executed once for several or even all of the contemplated destinations of the predicted traffic, such that the repetitive loop illustrated by operation **613** is eliminated in whole or in part. This unified approach would tend to reduce the overall processing time of generating the route table.

FIG. 7 depicts some salient sub-operations of operation **605** according to the illustrative embodiment. Because the illustrative embodiment generates a route table based on linear programming techniques, the present operation accordingly establishes the objective(s) to be maximized and the relevant constraints (including the ASR quality metric and its supporting data) to apply to the execution of the linear programming run.

Although the illustrative embodiment generates an initial route table based on linear programming that uses the objective and constraints set forth below, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein the objective and/or the constraints differ while still remaining within the scope of the present invention. Likewise, it will be further clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments that generate the route table without linear programming techniques such that the route table maximizes a profitability metric for the predicted traffic based at least in part on (i) the first threshold value of the ASR quality metric for the predicted traffic, wherein the ASR quality metric is based on a ratio of answered calls to call seizures, and (ii) the predicted traffic—while still remaining within the scope of the present invention. For example, in some alternative embodiments, the initial route table maximizes a profitability metric for the predicted traffic based at least in part on (i) the first threshold value of the ASR quality metric for the predicted traffic, wherein the ASR quality metric is based on a ratio of answered calls to call seizures, (ii) the predicted traffic, and (iii) the second threshold value of the ACD quality metric for the predicted traffic, wherein the ACD quality metric measures call duration per answered call.

At operation **701**, route table generator **207** establishes the objective to be maximized, illustratively a profitability metric. Illustratively, the profitability metric to be optimized is a total margin value encompassing all the allocated calls according to the route table, i.e., the per-route margin-per-minute value multiplied by the total number of call-minutes allocated to the respective route. Notably, to maximize the total margin, it is preferable to allocate more call-minutes to high-margin routes and fewer calls to lower-margin routes, though, as explained, there are quality considerations that also come into play here.

At operation **703**, route table generator **207** establishes one or more quality constraints. Illustratively, route table generator **207** establishes the first threshold of the ASR quality metric as a constraint here.

At operation **705**, route table generator **207** establishes one or more traffic constraints. Illustratively, route table generator **207** establishes the predicted traffic for each distinct destination for the given time period, e.g., 1500 calls to destination A during hour 0900, and 2000 calls to destination B during the same hour 900.

At operation **707**, route table generator **207** identifies the routes and/or the corresponding suppliers' telecommunication facilities that are candidates for the predicted traffic, e.g., routes **121**-**123** and **1021**-**1023** respectively.

At operation **709**, route table generator **207** establishes one or more call-carrying capacity constraints for each of the candidate routes, e.g., 150 call-minutes for route **121**, 200 call-minutes for route **122**, etc. The units are in call-minutes, though other units can be used as the implementers see fit. The call-carrying capacity figures are obtained from historical data as explained earlier.

At operation **711**, route table generator **207** obtains, for each candidate route, a cost characteristic and/or a profitability characteristic, such as a margin-per-call-minute value. Illustratively, route table generator **207** obtains a per-route margin-dollar-per-call-minute value for each candidate route.

At operation **713**, route table generator **207** executes a linear programming run that generates the route table based on the objective and subject to the constraints above; the resulting initial route table maximizes the objective and comprises at least one route chosen from the candidate routes to a destination such that at least some of the predicted traffic is allocated to the chosen route(s). Illustratively, FIG. **10**A depicts an initial route table **1001** that comprises routes to destinations A and B. Notably, according to table **1001** generated under the existing objective and constraints, some of the predicted traffic to destination A could not be allocated to a route (50 call attempts), and likewise, some of the predicted traffic to destination B also could not be allocated to a route (900 call attempts). Control passes out of operation **605** to operation **607**.

FIG. **8** depicts some salient sub-operations of operation **609** according to the illustrative embodiment.

At operation **801**, route table generator **207** identifies, from among the routes in the route table, those routes that have a predicted ACD value that exceeds the target ACD threshold currently in effect—any such route is designated a "retained" route.

At operation **803**, route table generator **207** calculates a measure of "excess predicted traffic," which is defined as the difference between the total predicted traffic for the given time period and the traffic that the route table has allocated to the retained route(s). Another way of looking at "excess predicted traffic" is that it comprises predicted traffic that (i) is either allocated to a route which falls short of the target ACD threshold or (ii) is unallocated in the route table. The "excess predicted traffic" is analyzed further below to determine whether by relaxing the governing quality metric targets, i.e., ASR and ACD thresholds, the route table can be adapted to yield improved results.

At operation **808**, route table generator **207** lowers the target ASR threshold by the first decrement value, illustratively decrementing 10% from 100%, resulting in a lowered target ASR threshold of 90% answer-seizure ratio. This operation relaxes the quality requirements for any non-retained routes that are candidates for the "excess predicted traffic."

At operation **807**, route table generator **207** lowers the target ACD threshold by the second decrement value, illustratively decrementing 10% from 10 minutes, resulting in a lowered target ACD of 9 answered-call minutes. This operation relaxes the quality requirements for any non-retained routes that are candidates for the "excess predicted traffic."

At operation **809**, route table generator **207** analyzes whether there any non-retained candidate routes that can carry some/all of the excess predicted traffic subject to the lowered ASR and the lowered ACD. This is determined by comparing the predicted ASR and the predicted ACD of a route against the lowered ASR and lowered ACD thresholds, respectively. When the answer is affirmative, route table generator **207** infers that the current route table can be adapted and control passes to operation **811**. When the answer is negative, the present iterative operation (i.e., operation **609**) ends and control passes out of operation **609** to operation **611** (where route table generator **207** infers that no further optimization of the current route table can be found).

FIG. **9** depicts some salient sub-operations of operation **811** according to the illustrative embodiment. Because the illustrative embodiment generates an adapted route table based on linear programming techniques, the present operation accordingly establishes the objective(s) to be maximized and the relevant constraints (including the quality metrics ASR and ACD and their supporting data) to apply to the execution of the linear programming run.

Although the illustrative embodiment generates an adapted route table based on linear programming that uses the objective and constraints set forth below, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments wherein the objective and/or the constraints differ while still remaining within the scope of the present invention. Likewise, it will be further clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments that generate the adapted route table without linear programming techniques such that the adapted route table maximizes a profitability metric for the predicted traffic based at least in part on (i) the lowered threshold value of the ASR quality metric for the predicted traffic, wherein the ASR quality metric is based on a ratio of answered calls to call seizures, (ii) the predicted traffic, and (iii) the lowered threshold value of the ACD quality metric for the predicted traffic, wherein the ACD quality metric measures call duration per answered call.

At operation **901**, which resembles operation **701**, route table generator **207** establishes the objective to be maximized, illustratively a profitability metric. Illustratively, the profitability metric to be optimized here is the same as the one in operation **701**, which is a total margin value encompassing all the allocated calls during the given time period according to the route table, i.e., the per-route margin-per-minute value multiplied by the total number of call-minutes allocated to the respective route. It will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments that use a different maximization objective in operation **901** than used in operation **701**.

At operation **903**, route table generator **207** establishes one or more quality constraints. Illustratively, route table generator **207** establishes the lowered threshold of the ASR quality metric, and also the lowered threshold of the ACD quality metric as constraints here.

At operation **905**, route table generator **207** establishes one or more traffic constraints. Illustratively, route table generator **207** establishes the "excess predicted traffic" for each distinct destination for the given time period as the constraint here.

At operation **907**, route table generator **207** identifies the non-retained routes and/or the corresponding suppliers' telecommunication facilities that are candidates for the "excess predicted traffic."

At operation **909**, route table generator **207** establishes one or more call-carrying capacity constraints for each of the non-retained candidate routes. As before, the units are in call-minutes, though other units can be used as the implementers see fit. The call-carrying capacity figures are obtained from historical data as explained earlier.

At operation **911**, route table generator **207** obtains, for each non-retained candidate route, a cost characteristic and/or a profitability characteristic, such as a margin-per-call-minute value. Illustratively, route table generator **207** obtains a per-route margin-dollar-per-call-minute value for each non-retained candidate route.

At operation **913**, route table generator **207** executes a linear programming run that generates the route table based on the objective and subject to the present constraints; the resulting adapted route table comprises (i) the retained routes, and (ii) at least one other route that satisfies the lowered quality threshold constraints, allocating some/all of the predicted excess traffic to the at least one other route. Illustratively, FIG. **10**B depicts an adapted route table **1002** that comprises routes to destinations A and B. Notably, according to table **1002** generated under the present objective and more relaxed quality constraints, all the predicted traffic for the given time period has been allocated and no unallocated traffic remains. This result is to be contrasted with route table **1001** in FIG. **10**A, where fewer routes were chosen for the route table and consequently traffic remained unallocated; when route table **1001** would have been applied to route actual calls, the chosen routes would have proven to lack sufficient call-carrying capacity for all the call attempts. In contrast, route table **1002** in FIG. **10**B, has been adapted, based on relaxed quality constraints to have more routes that have sufficient call-carrying capacity for all the predicted traffic in the given time period. Notably, this is an iterative process that might require repeated iterations of operation **811** to successively relax the quality constraints and incrementally add more routes to carry the excess predicted traffic (or as much of it as feasible under the totality of constraints). Thus, the adapted table **1002** is an improvement over initial table **1001**. Control passes from operation **811** to operation **607**.

FIG. **10**A depicts an illustrative initial route table **1001** generated according to operation **605** of the illustrative embodiment. The present figure was also discussed above. Table **1001** comprises columns **1011**, **1012**, **1013**, and **1014**.

Column **1011** lists the distinct destinations for the given period of time. Destination identifiers are well known in the art. Here, destinations A and B are depicted.

Column **1012** lists the route identifier or some corresponding supplier facility that can carry calls. Here, outgoing routes **121**, **122**, **1021**, and **1022** are depicted.

Column **1013** lists the number of predicted call attempts allocated to each destination-route pair. Here, 750 call attempts are allocated to route **121** for destination A, 700 call attempts are allocated to route **122** for destination A, 1000 call attempts are allocated to route **1021** for destination B, and 100 call attempts are allocated to route **1022** for destination B.

Column **1014** lists the number of predicted call attempts for a destination that remain unallocated to an outgoing route. Here, 50 calls remain unallocated for destination A, and 900 calls remain unallocated for destination B.

FIG. **10**B depicts an illustrative adapted route table **1002** generated according to operation **811** of the illustrative embodiment. The present figure was discussed in more detail above. Table **1002** comprises columns **1011**, **1012**, **1013**, and **1014**.

Column **1011** lists the distinct destinations for the given period of time. Here, destinations A and B are depicted.

Column **1012** lists the route identifier or some other supplier facility that can carry calls. Here, outgoing routes **121**, **122**, **123**, **1021**, **1022**, and **1023** are depicted.

Column **1013** lists the number of predicted call attempts allocated to each destination-route pair. Here, 750 call attempts are allocated to route **121** for destination A (same as in table 1001), 700 call attempts are allocated to route **122** for destination A (same as in table 1001), and 50 call attempts are allocated to route **123** for destination A; 1000 call attempts are allocated to route **1021** for destination B (same as in table 1001), 100 call attempts are allocated to route **1022** for destination B (same as in table 1001), and 900 calls are allocated to route **1023** for destination B.

Column **1014** lists the number of predicted call attempts for a destination that remain unallocated to an outgoing route. Here, there are no unallocated predicted call attempts. The present table **1002** illustrates how the illustrative embodiment successfully blended particular quality considerations into the process of expanding the route choices in a route table, such that more calls can be successfully routed, subject to quality requirements, while retaining the operator's objective of maximizing profitability. As compared to table **1001**, table **1002** allocates all predicted traffic. 950 more calls are allocated in table **1002** as compared to table **1001**. Not only does this advantageously improve the call-handling capacity during the given time period, but additionally, because the routes in table **1002** were carefully chosen according to the ASR and ACD quality metrics and more calls are routed, the profitability of handling more calls is also improved, even if some of the routes in table **1002** have a lower margin than the originally-chosen routes in table **1001**. Illustratively, the margin-per-minute value for outgoing route **123** is lower than for routes **121** and **122**, and, the margin-per-minute value for outgoing route **1023** is lower than for routes **1021** and **1022**; even so, these lower-margin routes have been auto-blended into the route table **1002** according to the illustrative ASR and ACD analysis.

FIG. **11** depicts some salient operations of method **1100** according to the illustrative embodiment. Route server **209** is the entity within illustrative telecommunications system **200** that executes and coordinates the operations of method **1100** according to the illustrative embodiment of the call routing logic. Accordingly, telecommunications system **200** is responsible for both method **400** and method **1100**. It will be clear to those having ordinary skill in the art, after reading the present invention, how to make and use alternative embodiments of the present invention wherein one unified apparatus comprises the functionality of route table generator **207** and route server **209**, including the functionality of the quality auto-blend logic and the call routing logic; in such a unified embodiment, data is transferred internally.

At operation **1101**, route server **209** receives one or more route tables from route table generator **207**, for one or more time periods wherein the respective route tables are to be in effect. Illustratively, route server **209** receives route table **215** from route table generator **207**.

At operation **1103**, route server **209** established the received route table at the appropriate time as the operative route table for the applicable time period. Illustratively, route server **209** establishes the contents of route table **215** as the operative route table **217**.

At operation **1105**, during the applicable time period, e.g., the 0900 hour, route server **209** routes calls according to route table **217**. Thus, for each incoming call during the 0900 hour, route server **209** places the call on an outgoing route as specified by route table **217** and the respective call allocations in route table **217**. During call processing by the route server, the call allocations in the route table guide how actual calls are routed to which route in order to maintain the relative allocations in the route table. Because the route table is based on the ASR and ACD quality metrics as described in detail above, when the route server applies the route table to the processing of actual calls, the routing of calls is likewise based on the ASR and ACD quality metrics.

At operation **1106**, route server **209** collects data about the ongoing traffic into and out of route server **209**, optionally performs statistical analysis on the collected data, transmits the raw data and the statistical analysis to other systems (e.g., traffic predictors, route characterizers, route table generator **207**, etc.), and also optionally archives the data for further retrieval and analysis. These techniques are well known in the art.

At operation **1107**, route server **209** repeats the above-enumerated sub-operations for the next applicable time period, e.g., the 1000 hour.

In regard to method **1100**, it will be clear to those having ordinary skill in the art, after reading the present disclosure, how to make and use alternative embodiments of method **1100** wherein the recited operations and sub-operations are differently sequenced, grouped, or sub-divided—all within the scope of the present invention. It will be further clear to those skilled in the art, after reading the present disclosure, how to make and use alternative embodiments of method **1100** wherein some of the recited operations and sub-operations are optional, are omitted, or are executed by other elements and/or systems, e.g., by route table generator **207**, or by a unified element that both generates the route tables and routes call according thereto.

It is to be understood that the present disclosure teaches examples of the illustrative embodiment(s) and that many variations of the invention can be devised by those skilled in the art after reading this disclosure. The scope of the present invention is to be determined by the following claims.

What is claimed is:

1. A method comprising:

generating, by a telecommunications system, a route table for a predicted traffic, wherein the generating is based at least in part on maximizing a profitability metric for the predicted traffic, subject to a constraint of a first quality metric for the predicted traffic, wherein the first quality metric is based on a measure of quality of a route,

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from a plurality of routes that are candidates for carrying the predicted traffic; and

routing, by the telecommunications system, a plurality of calls according to the route table.

2. The method of claim **1** wherein the measure of quality of a route is based on a ratio of answered calls to call seizures.

3. The method of claim **2** wherein the generating is further based on a value of a second quality metric for the predicted traffic, wherein the second quality metric measures call duration per answered call.

4. The method of claim **1** wherein the generating is further based on a capacity characteristic for each of the plurality of candidate routes.

5. The method of claim **1** further wherein the profitability metric is a total margin based on the number of allocated calls according to the route table.

6. The method of claim **1** wherein the route table maximizes the profitability metric based on at least one route in the route table being characterized by a higher cost than a minimum cost among the plurality of candidate routes.

7. A system comprising:

a route table generator that is configured to generate a route table for a predicted traffic based at least in part on maximizing a profitability metric for the predicted traffic, subject to a constraint of a first quality metric for the predicted traffic, wherein the first quality metric is based on a measure of quality of a route,

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from a plurality of routes that are candidates for carrying the predicted traffic; and

a route server that is configured to route a plurality of calls according to the route table.

8. The system of claim **7** wherein the measure of quality of a route is based on a ratio of answered calls to call seizures.

9. The system of claim **8** wherein the route table generator is further configured to generate the route table based on a value of a second quality metric for the predicted traffic, wherein the second quality metric measures call duration per answered call.

10. The system of claim **7** wherein the route table generator is further configured to generate the route table based on a capacity characteristic for each of the plurality of candidate routes.

11. The system of claim **7** further wherein the profitability metric is a total margin based on the number of allocated calls according to the route table.

12. The system of claim **7** wherein the route table generator is further configured to generate the route table such that the route table maximizes the profitability metric based on at least one route in the route table being characterized by a higher cost than a minimum cost among the plurality of candidate routes.

13. A method comprising:

receiving, by a route-table generator, a predicted traffic; and

generating, by the route-table generator, a first route table for the predicted traffic, wherein the generating is based at least in part on maximizing a profitability metric for the predicted traffic, subject to a constraint of a first quality metric, and on:

(i) a first threshold value of the first quality metric for the predicted traffic, wherein the first quality metric is based on a measure of quality of a route, and

(ii) a capacity characteristic for each of a plurality of routes that are candidates for carrying the predicted traffic;

wherein at least some of the predicted traffic is allocated in the route table to one or more routes chosen from the plurality of candidate routes.

14. The method of claim **13** wherein the measure of quality of a route is based on a ratio of answered calls to call seizures.

15. The method of claim **13** wherein the first quality metric measures call duration per answered call.

16. The method of claim **13** further comprising:

for each route in the first route table, computing, by the route-table generator, a predicted value of the first quality metric based on the first route table;

for each route in the first route table, computing, by the route-table generator, a predicted value of a second quality metric based on the first route table, wherein the second quality metric measures call duration per answered call;

when (A) the predicted value of the first quality metric for each route in the first route table passes the first threshold value, and (B) the predicted value of the second quality metric for each route in the first route table passes a second threshold value for the second quality metric, and (C) there is sufficient capacity among the routes in the first route table to carry the predicted traffic, routing, by a route server, a plurality of calls according to the first route table.

17. The method of claim **13** further comprising:

for each route in the first route table, computing, by the route-table generator, a predicted value of a second quality metric based on the first route table, wherein the second quality metric measures call duration per answered call;

when a route from the first route table has a predicted value for the second quality metric that passes a second threshold for the second quality metric, designating the route a retained route;

when a route from the first route table has a predicted value for the second quality metric that does not pass the second threshold, generating a second route table for the predicted traffic based at least in part on:

(i) a third threshold value of the first quality metric that is lower than the first threshold value, and

(ii) a fourth threshold value of the second quality metric that is lower than the second threshold value; and

wherein the second route table comprises (A) the retained routes from the first route table, and (B) at least one other route that has a predicted value of the second quality metric that passes the fourth threshold value and does not pass the second threshold value; and

routing, by a route server, a plurality of calls according to the second route table.

* * * * *